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An online explorative study on the learning uses of virtual reality among early adopters

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Dear Editors,

I am writing to submit our manuscript entitled *"Virtual Reality as a learning tool among early adopters: an explorative analysis"* for consideration for publication in *Journal of Visualized Experiments (JOVE) Journal*.

The manuscript has not been submitted for publication elsewhere. The corresponding author of this manuscript is Roberto Sánchez Cabrero (PhD. in Clinical Psychology), Professor in the Department of Psychology and Education at Alfonso X el Sabio University (Madrid, Spain), who can be contacted at rcabrero@uax.es.

The study describes the social and demographic profile of the early adopters of virtual reality viewers in Spain and, subsequently, it assesses the interest in the use as a learning tool of this technology.

For that purpose, an online questionnaire created *ad hoc* was administered to a sample of 117 participants. The relationships between twelve variables were analysed comparing means through Snedecor's F distribution, and the contingency tables through the Chi-squared test and Somers' D.

Among other issues, it was concluded that the virtual reality user profile at present corresponds to a person older than 35, mainly men, with higher education and having acquired their viewer no longer than one year ago.

Concerning the vision that these users foresee about the pedagogical potential of virtual reality, they mainly show an interest in using the virtual reality as a learning method and they feel optimism regarding the future in this field. Only a few of them currently use virtual reality for this aim and it can be concluded that the main reason is the lack of applications and experiences in this field at present.

We hope this manuscript fulfills the expectations of the journal to be published in *Journal of Visualized Experiments (JOVE) Journal*.

Yours sincerely,

PhD. Roberto Sánchez Cabrero

TITLE:

Online Explorative Study on the Learning Uses of Virtual Reality Among Early Adopters

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KEYWORDS:

virtual reality, ICT, early adopters, education, e-learning, learning tools

SUMMARY:

This article describes the profile of Spanish early adopters of virtual reality and their interests and preferences regarding learning and educational applications for this technology. To this aim, we designed an online questionnaire and interviewed 117 users of the main virtual reality forum on the Internet.

ABSTRACT:

Virtual reality (VR) has shown great educational potential because it makes it possible to simulate any desired situation or event, thus playing an important role in addressing current educational challenges. Despite the unlimited learning possibilities that VR may offer, unless users are willing to apply virtual devices to education, the investment of time, money, and effort will be fruitless. It is therefore crucial to assess the educational interest of the first generation of VR users and to identify their current needs. To this end, in this study we designed an online questionnaire and applied it through the SaaS (Software as a service) of a private server. The sample consisted of 117 early VR adopters recruited via a main portal of communication and information technologies in Spain. In order to engage participants, we posted a thread in the main forum, which is dedicated to the advances and potential uses of VR. Once the responses were gathered, we analyzed the relationship between 12 variables (mean contrasts with Snedecor's F, and contingency analysis with chi-square and Sommer's d). The results showed that the current profile of a VR user is a male over 35 years old, with university studies, and who has purchased his viewer recently (<1 year). As for the learning and teaching applications that these users were

interested in, only 13.7% of the participants in this study use VR for educational purposes, although 28.2% were interested, indicating that perhaps the lack of applications or learning experiences may be hampering the use of VR within education. Almost half of the early adopters surveyed would like to learn using VR technology and are somehow optimistic about the relationship between VR and education, particularly those who are younger.

INTRODUCTION:

Information and communication technologies are evolving rapidly to make it easier for human beings to communicate and relate to each other, and the distance and time that someone needs to contact and interact with someone else is reduced. However, this connection, when made through technology, is still much poorer and limited than face-to-face contact[1].

VR provides a major advance in simulating physical experiences, allowing us to interact within a computer environment that feels real, giving us a sense of presence and closeness. This is one of the main reasons why VR occupies a privileged place in the plans of technology development of important companies. However, if they want to meet the needs of their potential customers, research on VR is essential to accomplish this goal[2].

In Spain, as in most Western societies, the emergence of the first commercial head-mounted displays (HMD) capable of providing acceptable immersion experiences[3] increased the interest in VR, leading to the development of software and VR experiences. For instance, some of the most important VR studies are currently Spanish, such as Vertical Robot, awarded multiple times for its products[4], or the Tessera Studios and Dual Mirror Games, all of them of international prestige. The educational and scientific spheres have also experienced a whole explosion of research and applied educational experiences from 2015 onwards, as shown in the review by Aznar-Díaz, Romero-Rodríguez, and Rodríguez-García[5].

Most universities are already aware of the crucial role that VR will play not only in the business and industry sector, but also in many scientific disciplines. Therefore, they are working on several research and innovation lines. For example, the Alfonso X el Sabio University is a pioneer worldwide in the use of VR simulation and augmented reality for training future doctors at the "UAX Virtual Simulation Hospital", unique in the world. Furthermore, this university applies VR in social, psychological, and educational research[6].

Since the popularization of the Internet a few decades ago, different educational methodologies have evolved towards the so-called e-learning that a growing number of universities are adopting[7,8]. This online learning system is aimed at developing distance learning through technological means, some of which were developed specifically for it, while others were incorporated and adapted for educational purposes. However, e-learning is not exempt from limitations when it comes to social interaction. In this sense, VR considerably reduces some of these shortcomings, making interaction between people easier and much more realistic than any other technology. Also, it takes advantage of all the possibilities that technology offers us, creating an almost infinite world of opportunities[3]. For instance, VR would allow us to travel through the universe, or along the seabed, to see dinosaurs, to observe the microscopic world,

or even to live emotions associated with certain experiences and social events in a simulated way. Therefore, VR could be a vital educational resource, helping teachers in their struggle to engage students with classroom topics [9-11].

However, not every aspect of VR is positive, and some downsides must be considered. As mentioned above, it would be useless to develop new and educational applications for VR if the potential trainees and students were not willing to use it or preferred other forms of e-learning, which could be narrower yet more aligned with their true interests and preferences. This is why the desired relationship between VR and learning not only depends on a world of exciting possibilities, but more importantly, on building this relationship upon real social needs and demands. We must bear in mind that VR was recently targeted by companies, and that less than 1% of the total worldwide population has used it. VR is also a technology that is still in its infancy and that cannot be understood if someone has not used it. This last point explains why VR is surrounded by so many prejudices that result either from ignorance or from the social fear of novelty[12,13].

To bridge this gap between potential uses of VR and actual demand, it is necessary to find out the expectations of those early adopters that purchase HMDs as soon as they are available in the market. These users are so powerfully attracted to technological innovations that they do not fear purchasing new products that may succeed or fail commercially. Therefore, unlike the rest of the population, the uncertainty that surrounds these new products does not affect them. For this reason, they are the first to discover the real possibilities of VR technology not yet established in the market. Consequently, they can provide information at a real user level, making them a valuable source for this study.

As a sampling method, we designed an online examination questionnaire that was filled out by a representative convenience sample of early adopters. Participants were recruited from a VR forum in a Spanish portal for communication and information technologies, digital leisure, and video games with more than 460,000 users and ten million monthly visits[14] (**Table of Materials**). We created a thread that received 2,000 visits in less than 2 months. The participants who accessed the questionnaire through the hyperlink responded to all the questions raised.

So far, in Spain this is the only website with a specific VR forum and more than 400 threads. Around 76,000 early VR adopters contributed messages and posts talking about all HMDs and platforms on the market[15]. For this reason, it is the best place to locate a homogeneous convenience sample of early VR adopters. According to Jager, Putnick, and Bornstein[16], when a subgroup is homogeneous on one or more sociodemographic factors, we can estimate results with clearer generalizability, providing more accurate accounts of population effects and subpopulation differences. It also eliminates possible biases common in heterogenous convenience sampling.

Our research goals were: (1) to study the profile of early adopters; (2) to examine the current state of VR as an educational technology, determining its degree of implementation; (3) to assess the acceptance of VR as a learning tool among early adopters.

PROTOCOL:

The protocol was submitted to the *Scientific and Ethical Committee of the Nebrija University*, in which a group of external experts reviewed and validated the process. To be able to participate in the study, we required a written acceptance informed consent as recommended by the Declaration of Helsinki[17], and it was made clear to the participants that they were not going to be involved in any experimental condition.

1. Design of the research instrument

1.1. Design a first draft of the questionnaire to meet the goals of the study (see a sample draft of the questionnaire provided as **Supplementary File 1**).

NOTE: The draft is created with Microsoft Word so it can be easily shared and modified. Questions included single, multiple, and open answers that were grouped in different thematic pages:

- Page 1: Accept a written informed consent obligatorily.
- Page 2: Demographic and social data of participants.
- Page 3: Descriptive information of previous VR experience as well as frequency of usage.
- Page 4: Subjective opinions and attitudes regarding VR.
- Page 5: Beliefs about the future of VR in education[3].

1.2. Send a draft to three social scientists and experts in technology that are external to the research team. The task of this committee is to review the experimental design, including ethical aspects and study design according to scientific guidelines. Also, they must validate the tool, considering aspects such as item comprehension (both questions and possible answers) in relation to the research goals.

1.3. Design a definitive version of the questionnaire (see **Supplementary File 2**), considering the suggestions made by the group of experts, so it can be submitted to a scientific and ethical committee along with a research report of the project.

NOTE: We obtained a positive evaluation both in the scientific and ethical areas of the Nebrija University committee (see the positive evaluation of the Nebrija University committee provided as **Supplementary File 3**). Also, there was a follow-up of the entire research process conducted by the same committee.

2. **Adapting the questionnaire to the online specification of a secure server**

2.1. Go to the main page of the software as a service (SaaS) with a private server (see **Table of Materials**) as a registered user of the platform (a registration process that must be done previously by adding personal data) and select **Create your survey from scratch** (see **Figure 1**).

[Place **Figure 1** here]

2.2. Create several pages of the questionnaire with the questions as well as with possible answers through the SaaS with a private server.

NOTE: In this step it is important to follow the recommendations received during the validation process by the group of experts. Also, in the instructions to the participants explain the question posed correctly and the type of answer (e.g., open, closed, one- or multiple-choice, etc.) that must be filled out (see **Figure 2**).

[Place **Figure 2** here]

2.3. Once the survey is created and saved (see the final questionnaire in **Supplemental File 2**), return to the main menu of the platform, select the questionnaire, and click on the icon **Open |Close Public Survey** to make it available to participants. After that, click on the icon **Obtain a Link to the Survey**, choosing one of several options by which participants will access the survey (e.g., a link embedded in an email or in a website, an iframe in a website, a pop up in a website, a link to computers of a call center, see **Figure 3**).

[Place **Figure 3** here]

NOTE: The criterion to develop the final tool were that (1) the questionnaire had to be completed with any electronic device with Internet access (e.g., tablets, personal computers, smartphones); (2) participants had to fill out the questionnaire just one time (to this end, the chosen system must be able to keep the information of users who have already participated by identifying the IP of the device that was used to access and complete the survey); (3) the selected system had to guarantee the anonymity of the participants at all times, allowing the data to be stored on a secure private server.

3. Sampling method

3.1. Go to the internet portal as a registered user (registration that must be done before completing all the personal data) and create a thread in the VR forum to detail the study (see **Table of Materials**). Post a hyperlink to the survey hosted in the online private server (see **Figure 4**).

[Place **Figure 4** here]

3.2. Go to the main page of the SaaS as a registered user of the platform, select the questionnaire created, and click on **Results**. On the pop-up menu, click on the icon **Questionnaire** to access the filled-out questionnaires directly. Eliminate all the incomplete or erroneous questionnaires through the SaaS (see **Figure 5**).

[Place **Figure 5** here]

3.3. Once the questionnaires reach the minimum number of participants (>100) after excluding incomplete questionnaires, go to the main page of the SaaS as a registered user of the platform, select the questionnaire, and click on the icon **Open/Close Public Survey** to finish the survey, so no one else can participate again (see step 1 in **Figure 3** again).

NOTE: The participants of this study were 117 VR users (21 females and 96 males) who owned a VR HMD (any available in Spain). Note that the final sample of 117 participants resulted from a screening and filtering of 578 questionnaires, of which we excluded many undelivered cases, as well as 36 questionnaires that were incomplete, without applying any other filter to the data. As for the mean age of the participants, $\mu = 36.91$ years old with a standard deviation of $\sigma X = 6.39$ ($\mu = 36.19$ and $\sigma_X = 7.50$ for females, and $\mu = 37.07$ and $\sigma_X = 6.15$ for males).

4. Statistical analyses

4.1. Go to the main page of the SaaS as a registered user of the platform, select the survey created and click on the icon **Results**. On the pop-up menu, click on **Export** and select the pop-up options of the report detailed (advanced spreadsheet format), in **Text** and with .csv extension (see **Figure 6**). Once the questionnaires are completed by the participants, export them to an email account in .csv format, so these can be kept in a safe, private, and protected place.

[Place **Figure 6** here]

4.2. Open the statistical software (see **Table of Materials**) and select **File Menu** | **Import Data** | **CSV Data**. Select the.csv file previously saved. This process allows transformation of the anonymous data into the analysis format required by the statistical software package (see **Figure 7**).

[Place **Figure 7** here]

4.3. Select the variables to analyze statistically ("Gender", "Age", "Educational Qualification", "Current Direct Relationship with Formal Education", "Previous Experiences with Sophisticated VR HMD", "Level of the Private VR HMD", "Number of Years Using VR", "Usage Frequency", "VR Usage for Educational Purposes", "Interest in VR for Educational Purposes", "Optimism Regarding the Future Pedagogical Possibilities of Virtual Reality" and "Optimism Regarding the Future Pedagogical Possibilities of Virtual Reality") and delete the rest of the information imported by the .sav file generated by the statistical software package.

4.4. Assess the internal consistency of the questionnaire with the **Alpha's Cronbach** with the statistical software package. To this end, select the **Analyze Menu** | **Scale** | **Reliability Analysis**, and transfer all the variables to the **Reliability Analysis** dialogue box. Finally, click on the **OK** icon to generate the desired output (see **Figure 8**).

[Place **Figure 8** here]

NOTE: The questionnaire had a high reliability and internal consistency, measured through the Alpha's Cronbach (α=0.826).

4.5. Carry out the descriptive analysis with the statistical software package. Explore descriptive statistics such as the arithmetic mean and the standard deviation for the quantitative variable "Age". Study frequency distribution in the rest of the variables. To carry this analysis out, select **Analyze Menu | Descriptive Statistics | Frequencies** and, after the output, **Analyze** | **Descriptive Statistics** | **Descriptive** (see **Figure 9**).

[Place **Figure 9** here]

4.6. Conduct One-Way ANOVA analysis with the statistical software package. To this end, select **Analyze Menu | Compare Means | One-Way ANOVA**, and in the **One-Way ANOVA** dialogue box put "Age" as the dependent variable and the rest of the variables as factors (see **Figure 10**).

NOTE: This process should be done for each of the nominal ("Gender", "Current Direct Relationship with Formal Education", "Previous Experiences with Sophisticated VR HMD", "VR Usage for Educational Purposes", "Interest in VR for Educational Purposes", "Optimism Regarding the Future Pedagogical Possibilities of Virtual Reality", and "Optimism Regarding the Future Pedagogical Possibilities of Virtual Reality") and ordinal variables ("Educational Qualification", "Level of the Private VR HMD", "Number of Years Using VR", and "Usage Frequency"). The output shows the statistical significance of "Age" as a discrete quantitative variable by comparing means with the Snedecor's F distribution (non-considering equality of variances).

[Place **Figure 10** here]

4.7. Conduct the Chi-squared test on contingency tables to test whether or not there is a relationship between the variables, and Somers' d to reflect the strength and direction of the associations. To this end, go to **Analyze menu | Descriptive Statistics | Crosstabs** and, in the Crosstabs dialogue box, click on **Statistics** and select options **Chi-squared** and **Somers' d** and click on **Continue** (see **Figure 11**).

4.8. In the **Crosstabs** dialogue box, transfer one of the nominal or ordinal variables as rows and the rest as columns. This process must be repeated for each of the variables in the rows, eliminating the ones already analyzed, to obtain all the correlations between them.

[Place **Figure 11** here]

REPRESENTATIVE RESULTS:

Table 1 presents the frequency distribution of the categorical variables (nominal, dichotomous, and ordinal variables) along with the mean and standard deviation of the interval scale variable "Age".

[Place **Table 1** here]

Results at first glance give us a profile of the users, shown in **Table 1**: males (82.1%), with university studies (64.1% postgraduates), related to education (76.9%), having previous experience with VR HMD (82.1%), who acquired a viewer during the last year (61.5%). As for the use of this technology, they were players of video game consoles VR HMD (46.2%), who use VR at least once a week (63.2%), but not for learning purposes (86.3%) and who did not seem to be interested in using this technology for learning (71.8%), although they did show interest in using it for educational purposes in the future (51.3%) despite the fact that they are not very optimistic about its future pedagogical possibilities (47%)[6]. Regarding the age of the participants, we can see in **Figure 12** that the mean was $\mu = 36.91$ with a standard deviation of $\sigma_X = 6.39$.

There were no statistically significant age and gender differences, as observed in **Table 2**. Only "Optimism Regarding the Future Pedagogical Possibilities of VR" varied significantly with "Age": Those who felt more optimistic about the future educational possibilities were younger ($\mu = 35.56$ and $\sigma_X = 5.74$) than those who did not ($\mu = 38.11$ and $\sigma_X = 6.74$)[9].

[Place **Figure 12** here]
[Place **Table 2** here]

Table 3 reports the values of the contingency tables using the Chi-squared test and the Somers' d, showing whether the correlations observed were significant and their direction (positive or negative).

[Place **Table 3** here]

Notice that a number of nominal variables were recoded and given ordinal values. This was done to see the relationship between gender (male/female) and other variables. In other words, the integer given to each condition does not transform the variable into a quantitative one, but simply serves to know instantly the trend shown by the results towards one or another condition. Otherwise it would be impossible to establish if being a man or a woman was directly or indirectly associated with the rest of the variables. A similar process was done with every binary variable, giving the higher score to the category "Yes"[9].

The Chi-squared test and Somers' d tests run on the contingency table outline the relationship that exists between some variables. For instance, females were educated at a higher level, a larger number of women were also related to the field of formal education, and more females reported using VR for learning purposes too. As for males, they used VR more frequently, and have tried the sophisticated VR HMDs.

A positive and significant relationship between formal education and the level of studies was found, as well as a significant and negative association between having tried a sophisticated VR HMD, viewer devices owned, and the frequency of VR usage. It was clear that the frequency of usage was significantly and directly associated to having tried a sophisticated VR HMD and to the number of viewer devices owned. The same variable was significantly and inversely associated

to the educational qualification of the VR user. There was also a significant, strong, and direct relationship between having tried a sophisticated VR HMD and the number of viewer devices owned [9].

As for the variables that were directly related to the usage and inclinations for VR as a learning tool, we can see a strong and positive correlation, since a "Yes" answer to having an interest in the usage of VR as a learning tool was significantly and directly associated to learning through VR in formal education. They were also associated with currently using VR as a learning tool and being optimistic about the future educational possibilities of VR[9].

The contingency table also shows a statistically significant and nonlinear (or second-degree) association with the Chi-squared analyses but not with Somers' d. This situation was due to some of the categories of a variable having a partial influence over another variable, such as "Number of Years Using VR". As for the variables that assessed which users had used VR recently, results showed that the interest in VR is still developing. More specifically, we can see that the usage frequency was high, but interest or preferences change depending on the willingness to try all the VR possibilities.

As for the "VR HMD Devices Owned" we can see gender differences in "Video Game Console" (see **Figure 2**), and in "Current Use of VR as a Learning Tool" (see **Figure 3**). Among users of game consoles VR HMD (e.g, Sony PSVR) there were no women, and they were not interested in the use of the VR as a learning tool. This points to a strong gender difference in entertainment and leisure[9].

[Place **Figure 13** here]
[Place **Figure 14** here]

FIGURE AND TABLE LEGENDS:

Figure 1: How to create the questionnaire from scratch. (1) Click on **New Survey** icon; (2) Select **Create Your Survey from Scratch**.

Figure 2: How to design the questionnaire. (1) Edit the survey; (2) Add and configure pages and questions; (3–5) Develop pages, questions, and answers.

Figure 3: How to obtain a link to the survey. (1) Open the survey; (2) Click on **Obtain a Link to the Survey** icon; (3) Select the chosen method.

Figure 4: How to launch a thread in the VR forum. (1) Click on the **Sistemas VR** icon; (2) Click on **NUEVO HILO** icon; (3,4) Write a post with the questionnaire link included.

Figure 5: How to eliminate all the incomplete or erroneous questionnaires. (1) Click on **Results** icon; (2) click on **Export** icon; (3) Eliminate all the incomplete or erroneous questionnaires.

Figure 6: How to export data to use in the statistical software package. (1) Click on **Results** icon; (2) Click on **Questionnaires** icon; (3) Select **Text** and **csv** in the **Detailed** option.

Figure 7: How to import data in the statistical software package. Select **File Menu | Import Data | CSV Data**.

Figure 8: How to assess the internal consistency of the questionnaire. Select **Analyze Menu | Scale | Reliability Analysis**.

Figure 9: How to carry out the descriptive analysis of the data. Select **Analyze Menu | Descriptive Statistics | Frequencies** and, after the output, **Analyze | Descriptive Statistics | Descriptive**.

Figure 10: How to conduct One-Way ANOVA analysis. Select **Analyze Menu | Compare Means | One-Way ANOVA**.

Figure 11: How to conduct Chi-squared and Somers d test. (1) Select **Analyze Menu | Descriptive Statistics | Crosstabs**; (2) Select **Chi-squared** and **Somers' d** options.

Figure 12: Age and gender pyramid. This figure has been republished from Sánchez-Cabrero et al.[9]

Figure 13: VR HMD devices owned and gender. Green = Woman; Blue = Man. This figure has been republished from Sánchez-Cabrero et al.[9].

Figure 14: VR HMD devices owned and current use. Green = Current use of virtual reality as a learning tool; Blue = No current use of virtual reality as a learning tool. This figure has been republished from Sánchez-Cabrero et al.[9].

Table 1: Frequency distribution of the variables considered in the study. This table has been modified from Sánchez-Cabrero et al.[9].

Table 2: Age comparison of means over the rest of the variables through ANOVA test. Abbreviations, df = Degrees of Freedom; F = Snedecor's F; p-value = probability value or significance. *Comparison of means is significant at the level of 0.05. This table has been modified from Sánchez-Cabrero et al.[9].

Table 3: Contingency table using the chi-squared test (first value in each cell) and Somers' d (second value in each cell). Abbreviations, EQ = Educational Qualification; CRFE = Current Direct Relationship with Formal Education; PEV = Previous Experiences with Sophisticated VR HMDs; LPV = Level of the Private VR HMD; YUV = Number of Years Using VR; UF = Usage Frequency; UEP = VR Usage for Educational Purposes; IEP = Interest in VR for Educational Purposes; IUF = Interest in the Use of VR in Formal Education in the Future; OFP = Optimism Regarding the Future Pedagogical Possibilities of VR. * Correlation is significant at the level of

0.05. ** Correlation is significant at the level of 0.01. This table has been modified from Sánchez-Cabrero et al.[9].

DISCUSSION:

This study explores the profile of Spanish early adopters of VR, assessing their interest in the use of VR as a learning tool. Therefore, along with other studies, it offers a fresh perspective on the real possibilities of VR and its applications to the classroom[9].

The users of VR devices live literally everywhere, so there is not a physical place to identify and locate them. For this reason, the only possible way to find them is through VR forums and websites that VR users visit to find information. In conclusion, not only did we need to use the virtual space to survey VR users, but it was also mandatory to proceed with an online questionnaire.

Finding the sample was complex because the first VR HMDs have been on the market for less than 3 years. It is worth mentioning that we should not mistake the consolidation of technology for its popularity: VR may be fairly popular despite most people having never tried it. This narrowed the population and sample to be studied. Finding VR users was another difficulty to overcome, because they form a heterogeneous group with different interests and socio-demographic characteristics and are hard to reach and locate. Also, they use different VR head-mounted displays (e.g., PlayStation VR: PSVR, Oculus Rift, HTC Vive, Windows Mixed Reality: WMR) and platforms (e.g., personal computers, Sony PlayStation 4, smartphones)[9] which makes it even harder to find them.

An online questionnaire was the only possible way to examine early VR adopters' preferences and interests in the use as a learning tool, because the dispersion of users in different locations and systems makes any face-to-face consultation or any other methodology common in the social sciences, such as interviews or focus groups, impossible. However, this method is not without limitations, since the participants' answers were limited to the questions, most of which were structured.

In addition to this, the real number of Spanish VR early adopters is difficult to know because most manufacturers do not make the information about their sales public for fear of discouraging potential investors or clients. Nonetheless, we can estimate this number if we have a look at indirect sources. For instance, in 2018 less than 4 million VR HMDs were sold on the worldwide market[18], which makes users of these technological applications, software, and video games less than 1% of the total population[19] (i.e., approximately 42% of the worldwide population[20]. Therefore, less than 5 per thousand of the population can be regarded as early adopters.

One of the main implications of this study lies in the relationship between the educational field and VR, which is at a critical moment[21]. VR technology is now taking its first commercial steps, a fact that explains why efforts are currently directed at entertainment and leisure[18,19]. The results of this study show that users' interest in entertainment is much greater in VR HMDs than in video

consoles (PSVR). Also, this interest is stronger in males who use their laptops or computers more frequently. As for the early adopters, learning is not a priority for them, and those who are interested find themselves with very few VR options. This can be seen, for instance, in the *Oculus Store* that has a very small number of VR educational applications[22]. Yet, its current usage is far from being insignificant, with 13.7% of use.

According to some indicators analyzed by the IDC Corporate USA[21], the sales of VR devices has increased 27.2% during the first quarter of 2019 compared to the same period of 2018. This has occurred despite the fact that it was believed that the sector had stagnated. This shows how the VR industry is growing at an even faster rate than expected. And this is surely due to the existence of new viewers such as the Standalone VR HMD *Oculus Quest* that was launched to the market in the beginning of 2019.

Our results also indicate that interest in using VR for educational purposes is much higher than its actual use. Also, half of the users felt optimistic when asked about the educational possibilities of VR. This, along with the fact that VR is still entering education despite unideal conditions, may be taken as a positive fact. This conclusion is similar to that of Yildirim's[11] or Fernández-Robles[10], who also found that students were interested in the use of VR as an educational tool. According to our results it can be concluded that the lack of VR educational applications may be impeding advances and somehow affecting the interest of potential users. Consequently, the future of the relationship between education and VR may depend on the growth and evolution of new applications within this field. Without them, we run the risk of wasting an excellent opportunity.

However, how this relationship between education and virtual reality will progress in the future depends on application development and on the evolution of this sector. Our results show that, on the one hand, the lack of applications may hinder the interest of users. On the other hand, without the applications, these first opportunities could quickly disappear.

VR accessibility is another major issue, because most teachers who participated in this study showed a preference for low-cost kits and reported a sporadic use. Perhaps if costs were reduced, professionals in the educational field would prefer better equipment and would also increase the time of use, which, in turn, could change their minds about VR as a learning tool[9]. However, given that VR is just emerging within education, it may be too soon to make any conclusive statements. Consequently, we must wait for the consolidation of this technology if we are to make more accurate evaluations of its virtues, potentials, and shortcomings.

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DISCLOSURES:

The authors have nothing to disclose.

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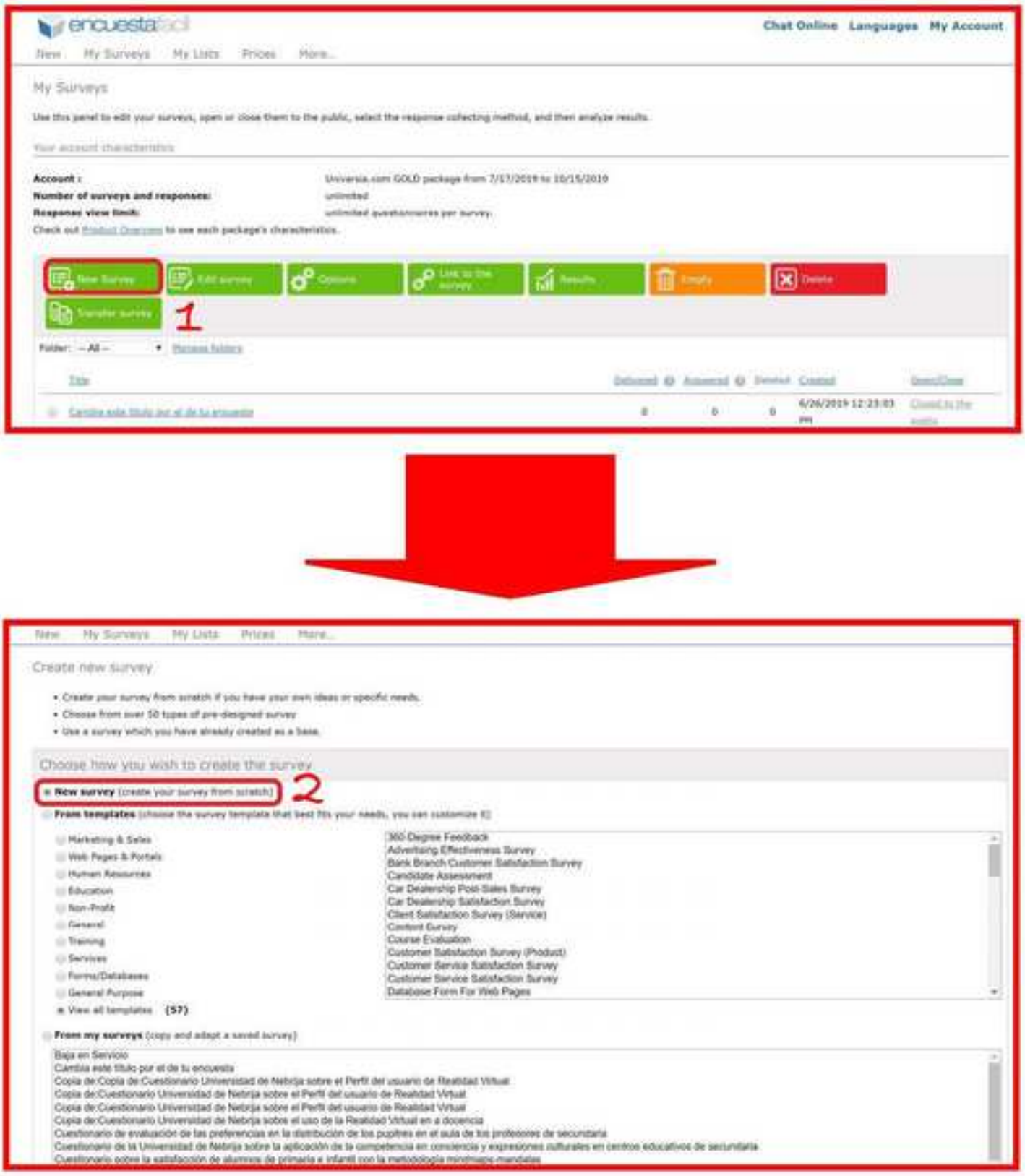

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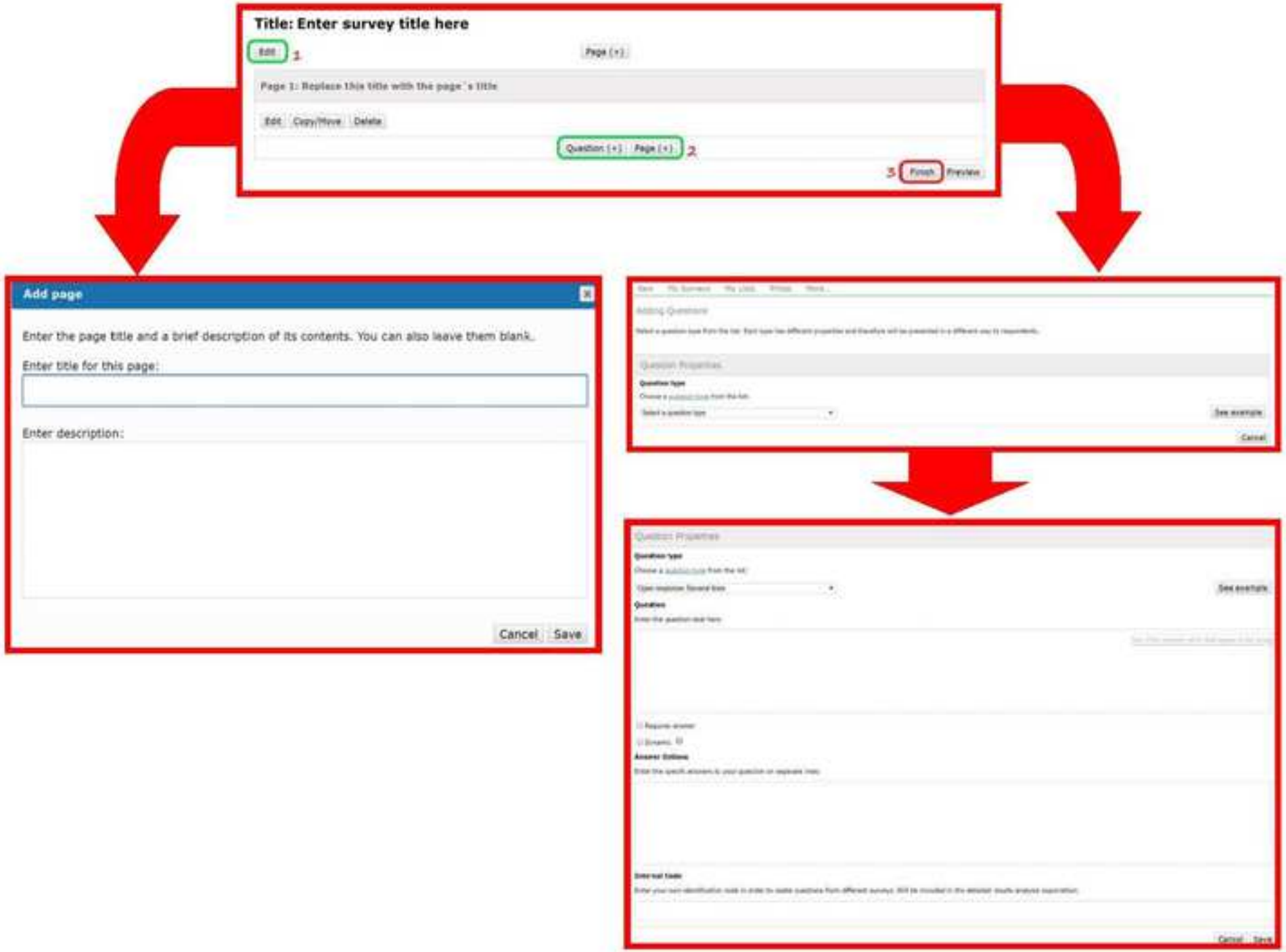

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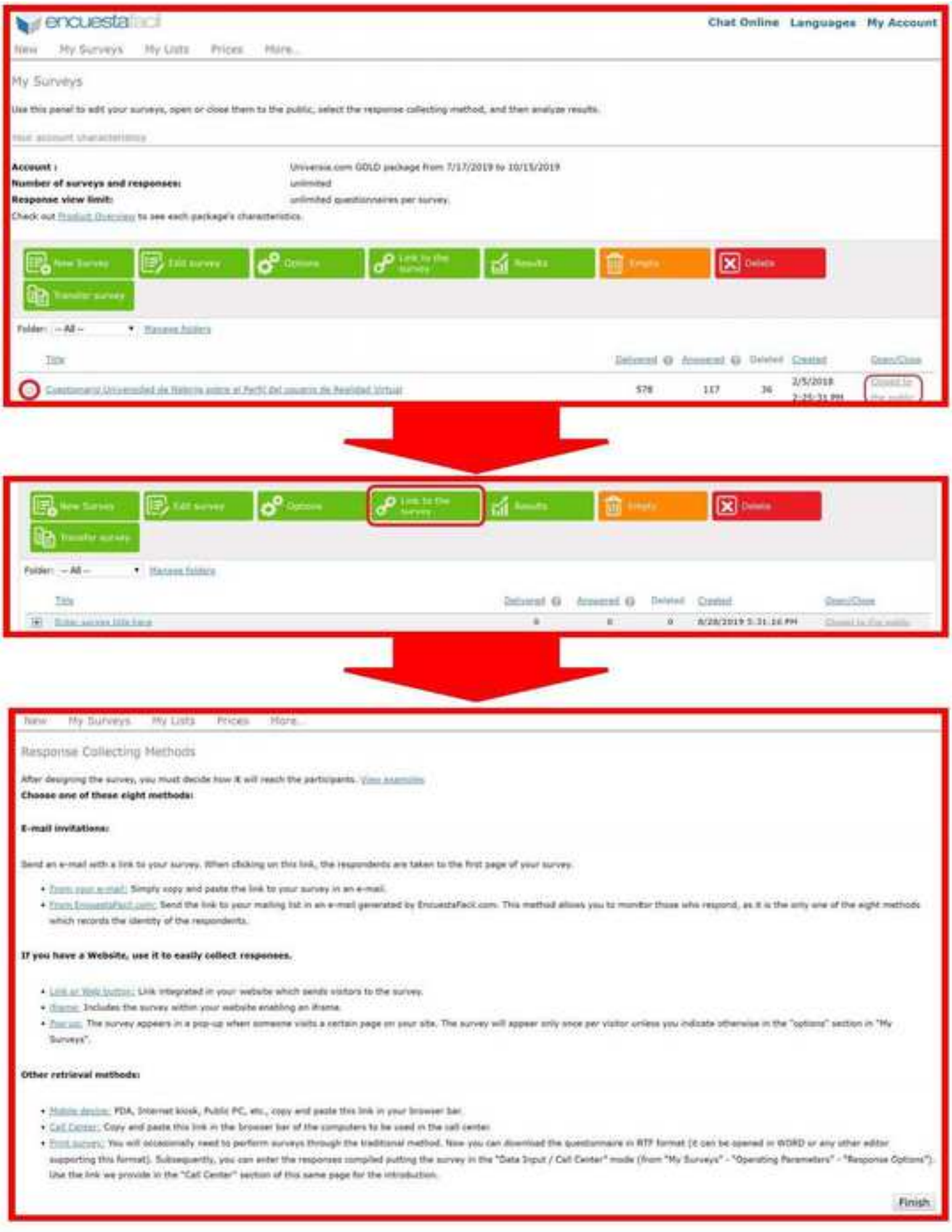

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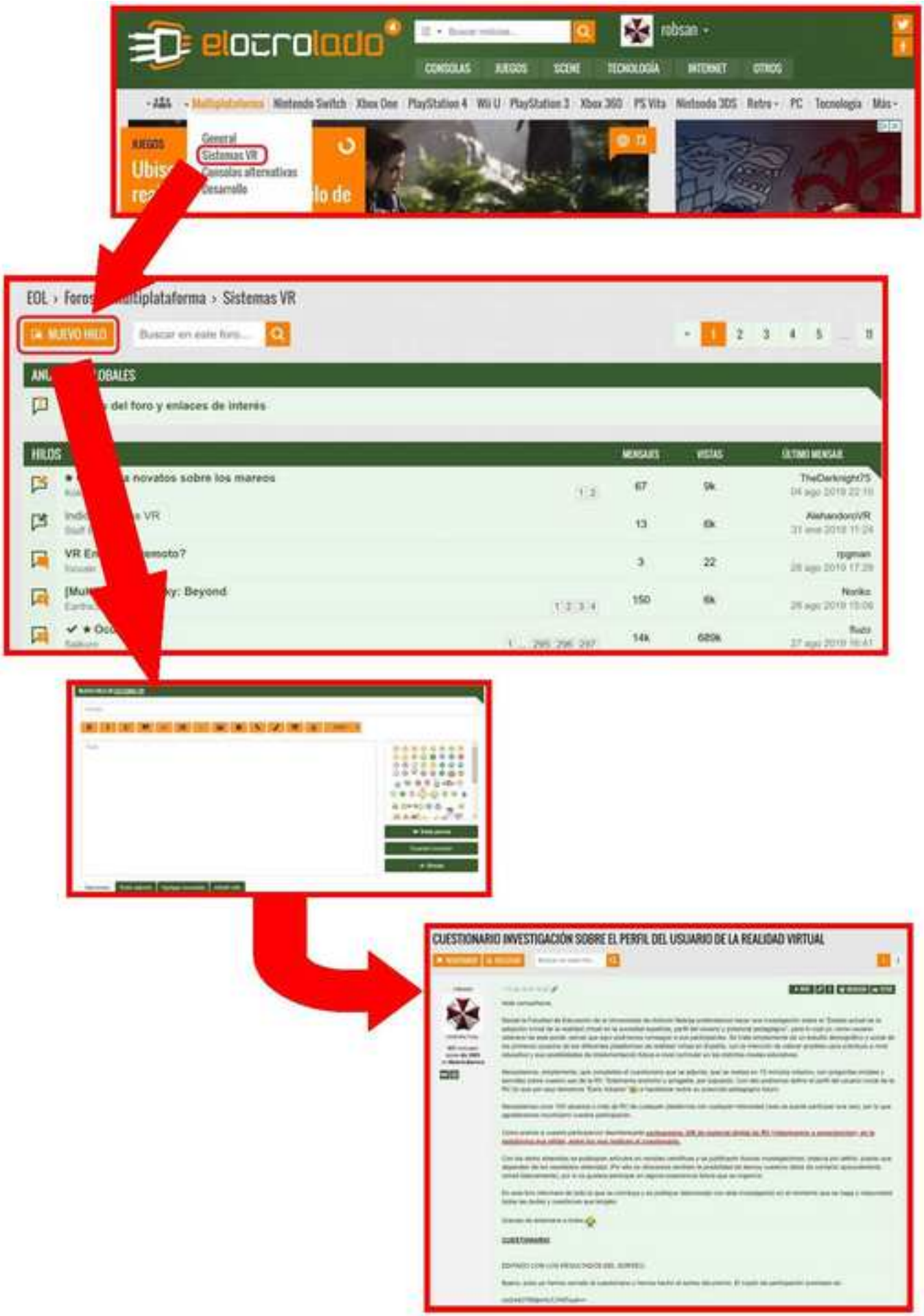

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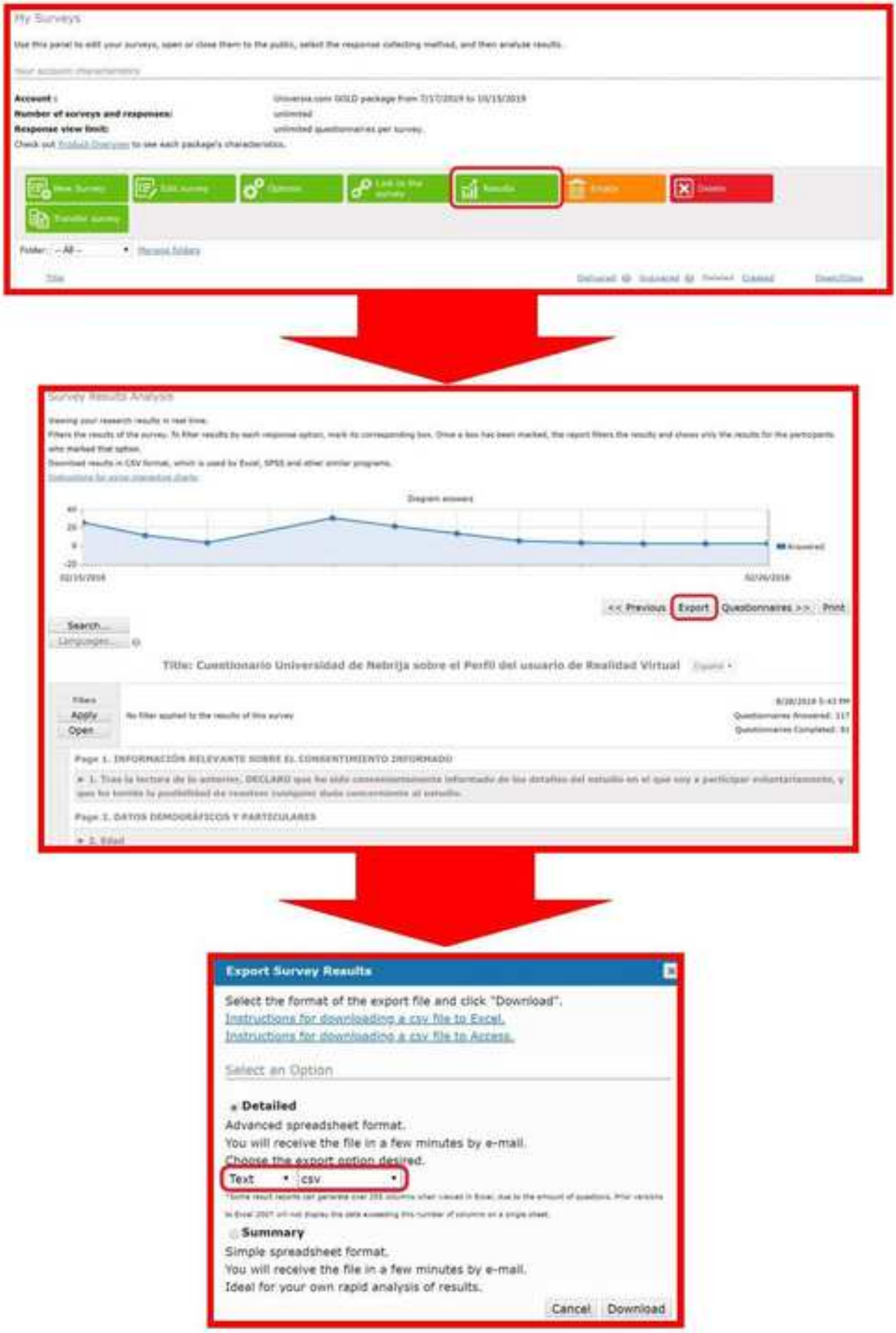

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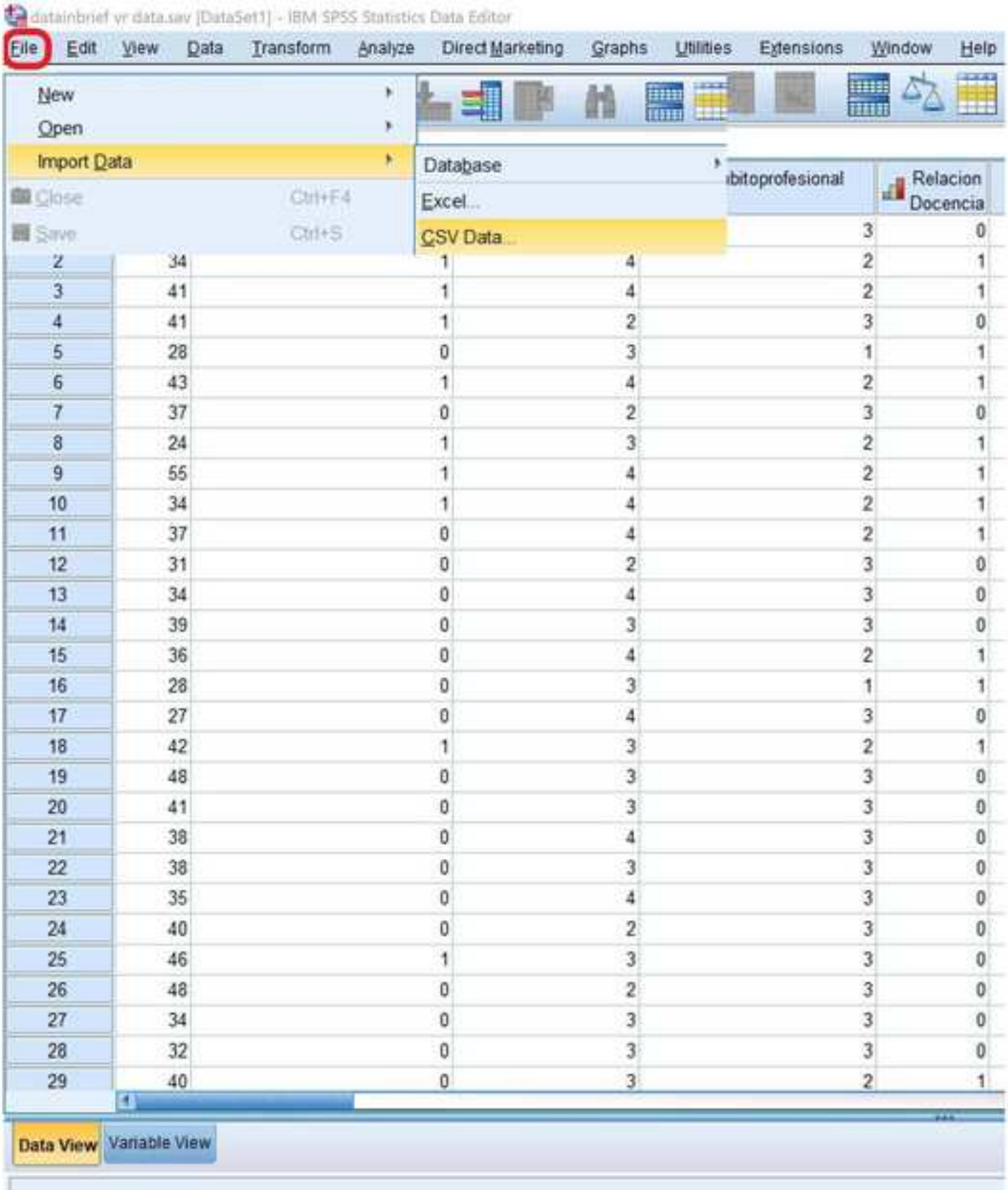

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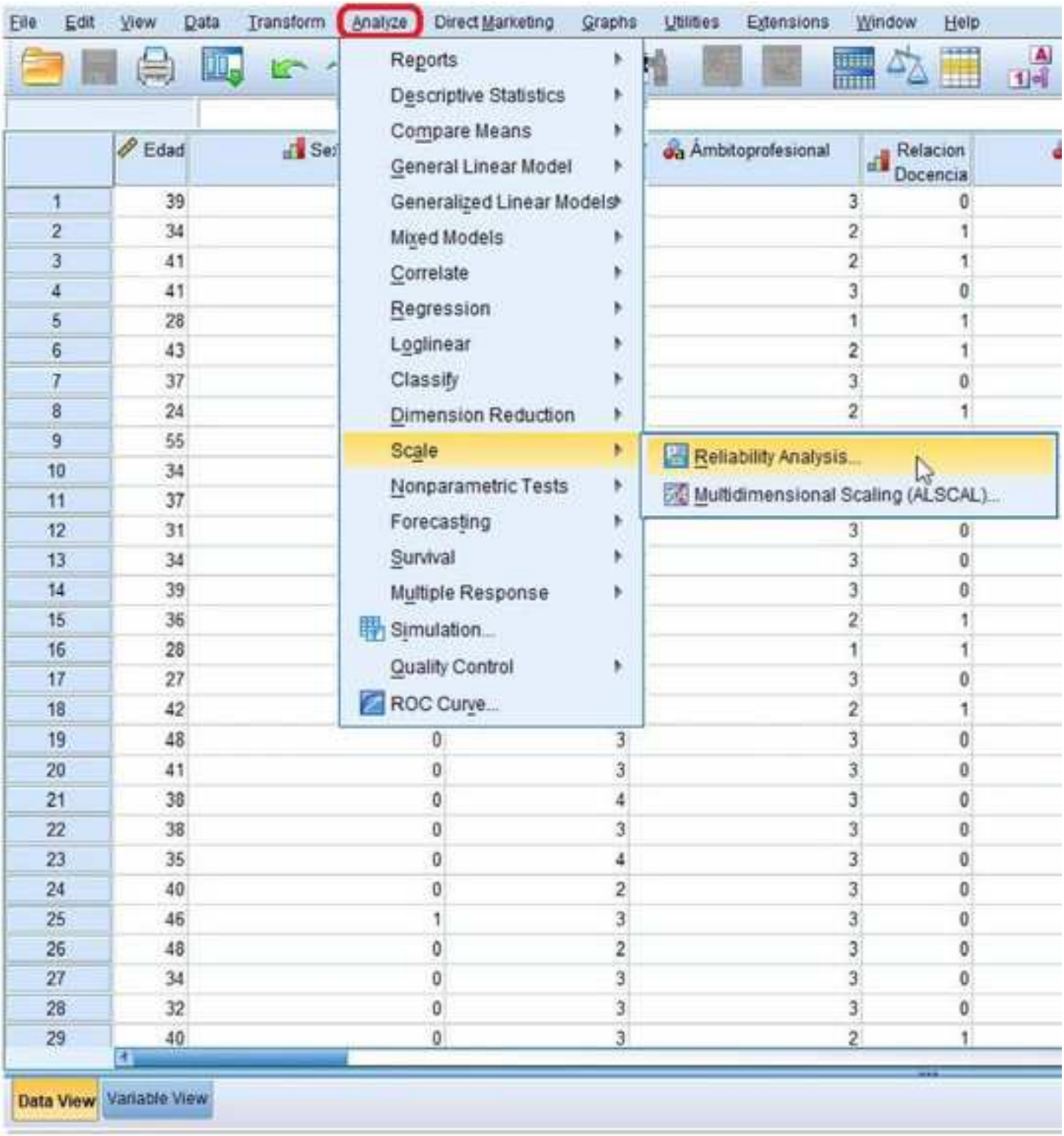

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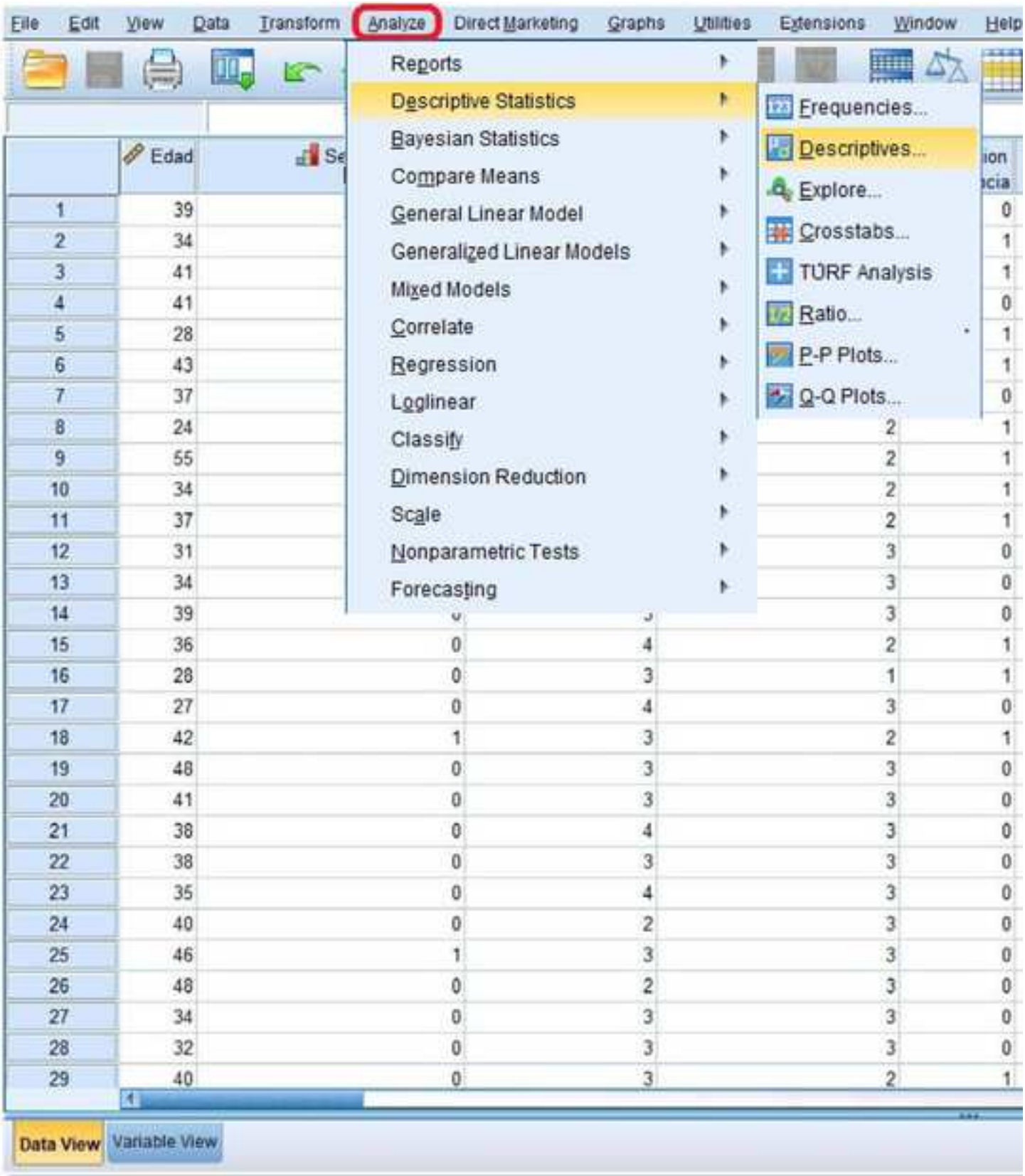

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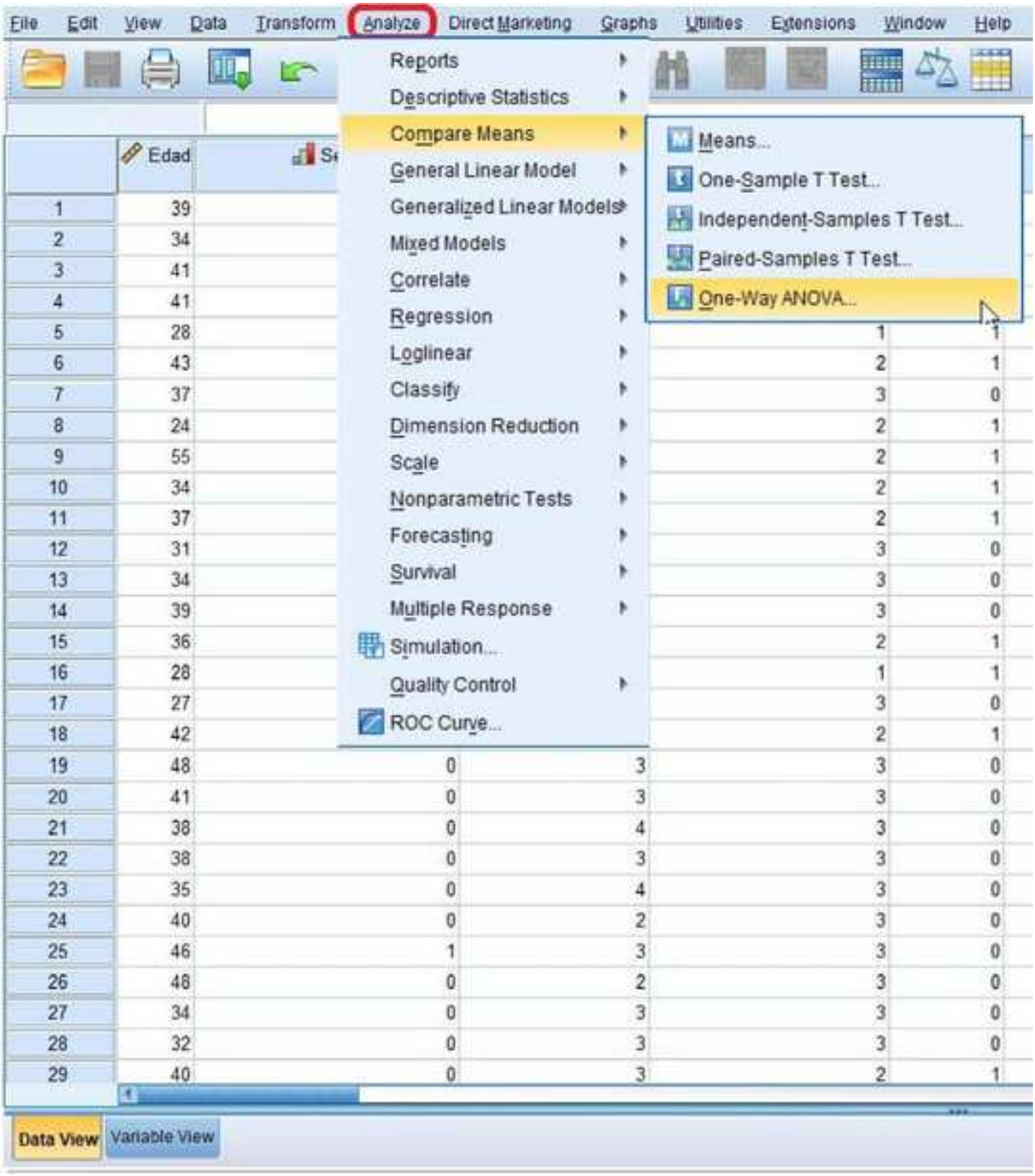

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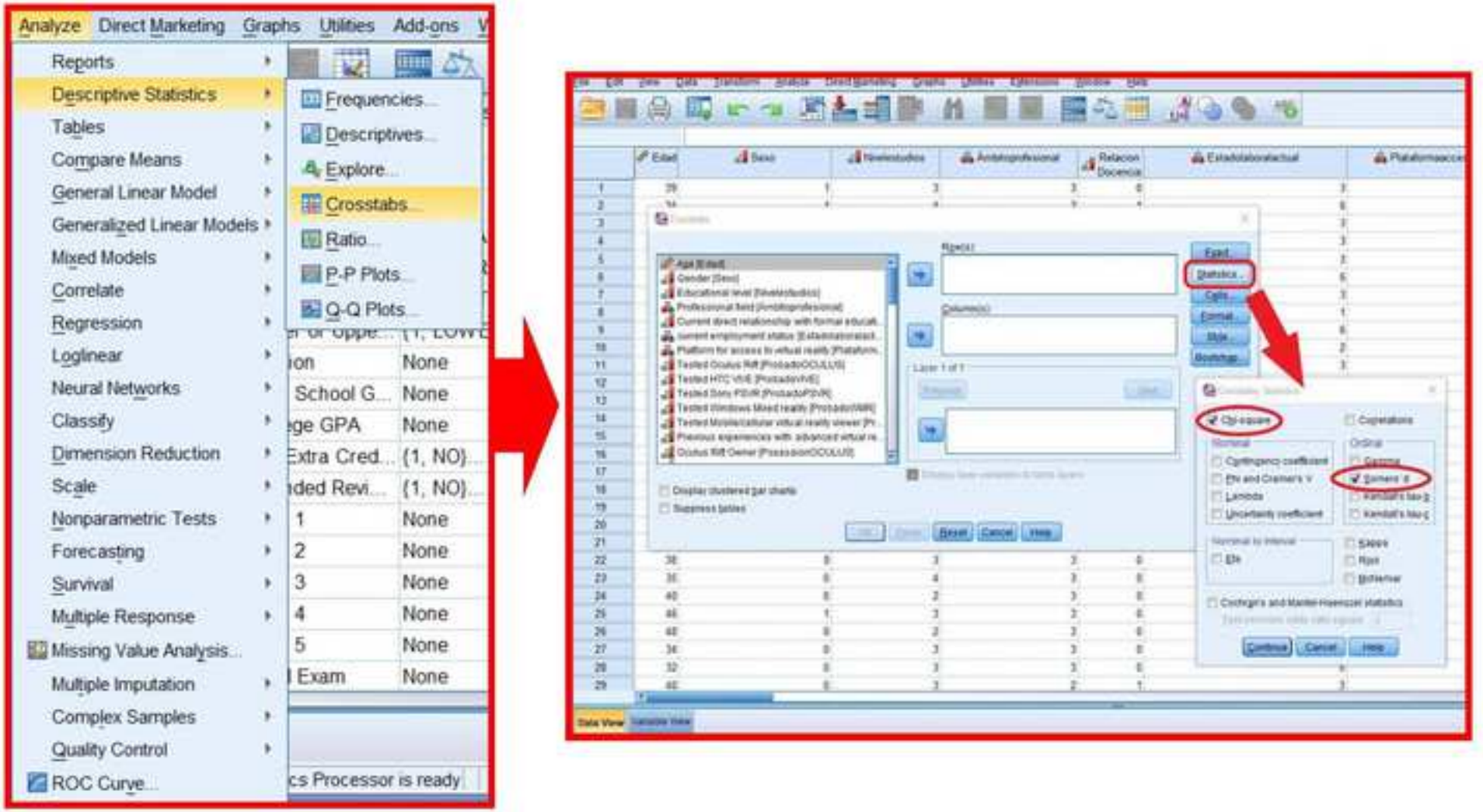

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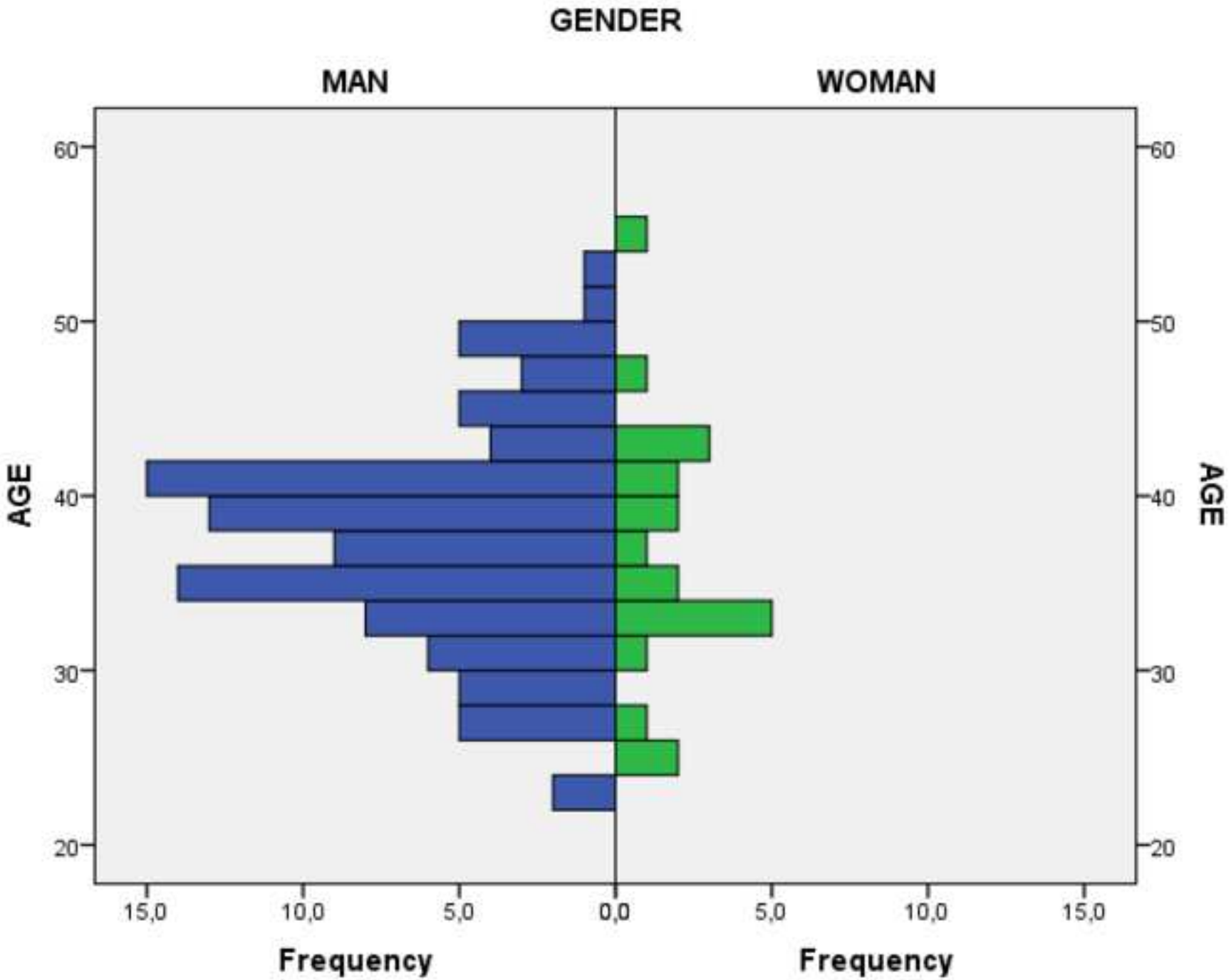

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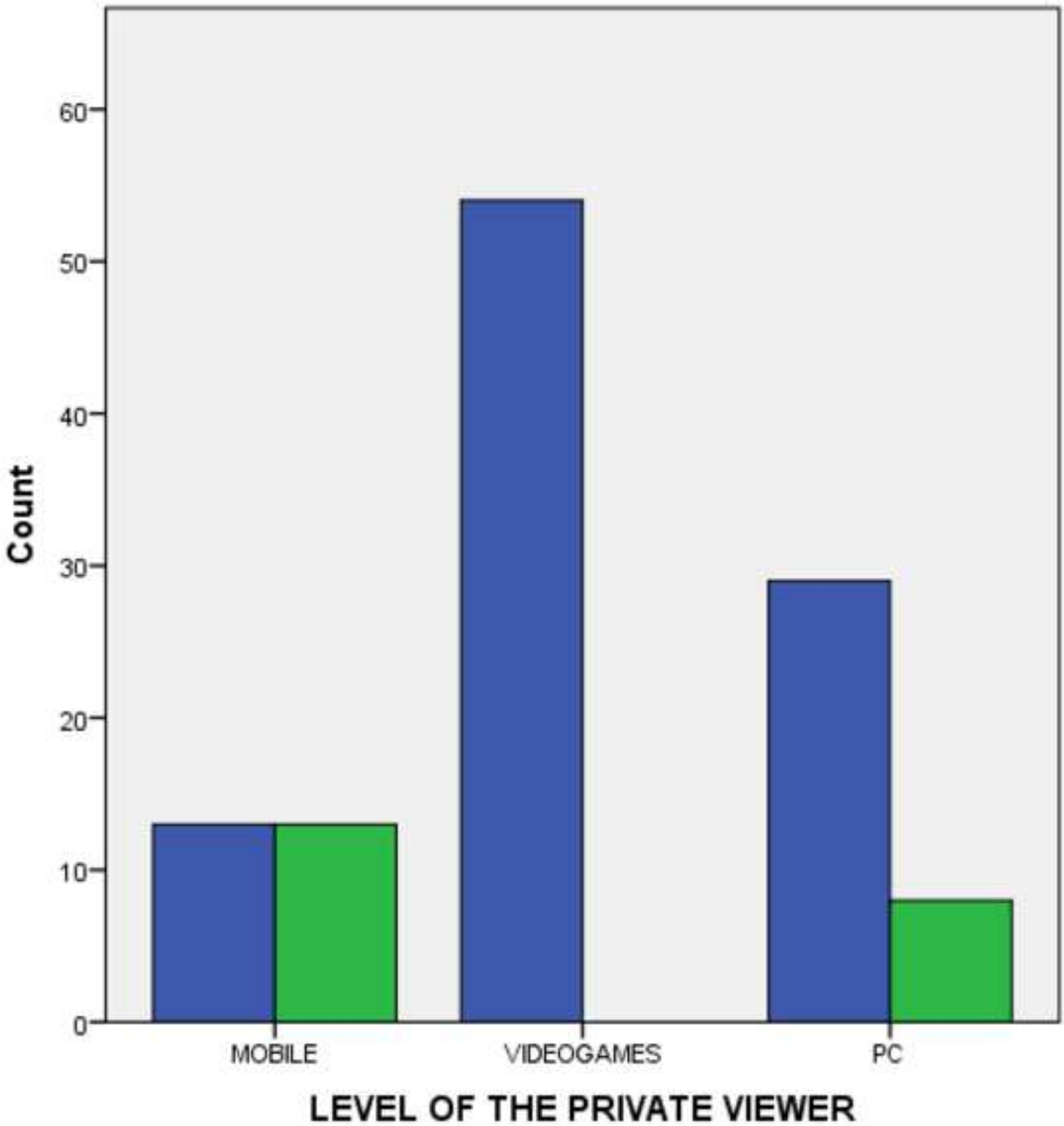

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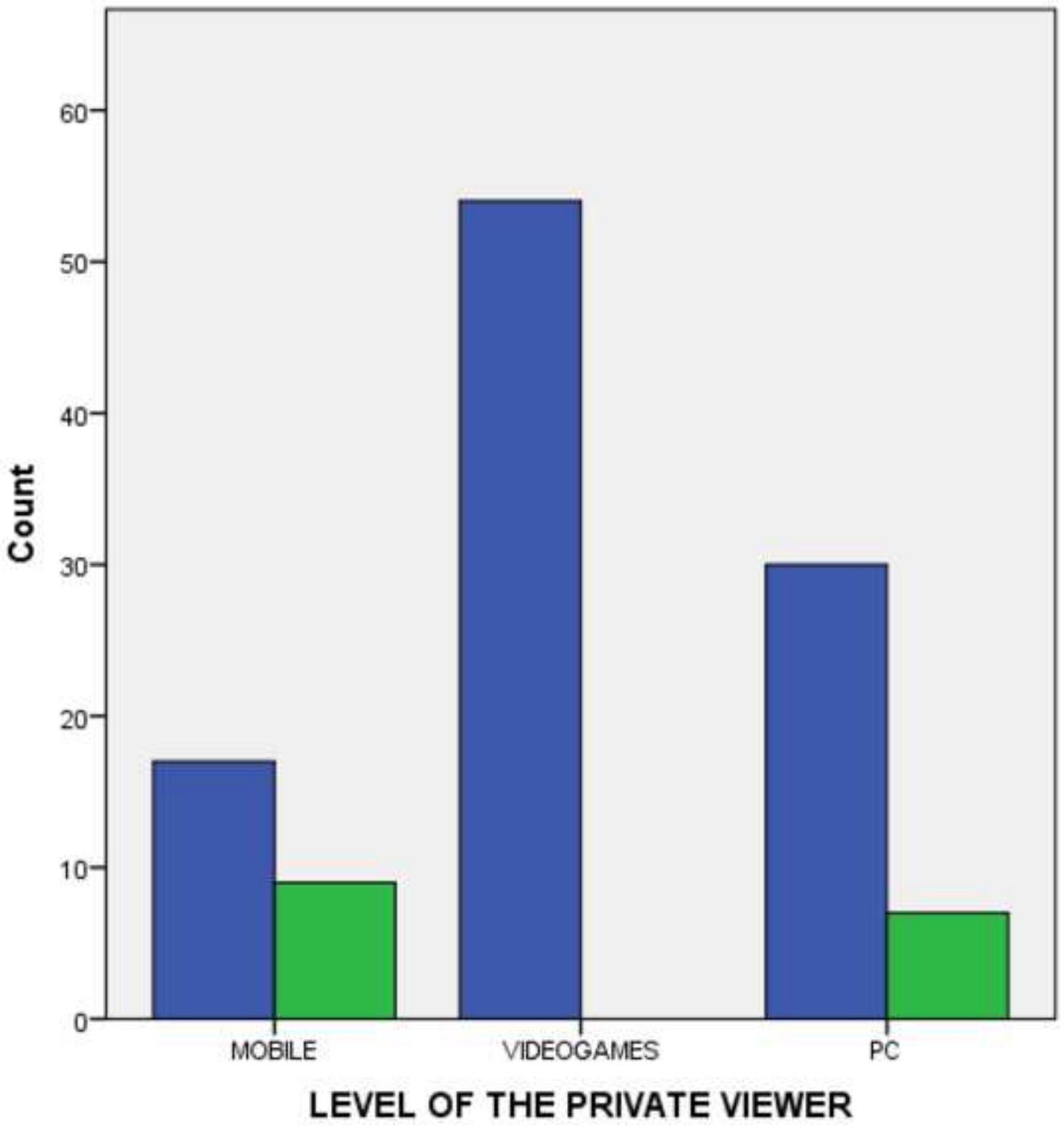

Table 1 Click here to access/download;Table;Table 1_8S.xlsx

CATEGORICAL VARIABLES
Gender
It is a dichotomous variable i.e., being man or woman.
Educational qualification
Education was treated as an ordinal categorical variable following four levels: primary, secondary, university and postgraduate.
Current direct relationship with formal education
This was treated as a Y/N dichotomous variable (YES, if the participant was either a teacher or student, and NO for the rest of cases).
Previous experiences with sophisticated VR HMD
Response to the question 'Which kind of virtual reality platforms have you try?'. It was treated as a Y/N dichotomous variable (YES, if the participant was familiar with special viewer for video game or personal computers, and NO if s/he was only familiar with VR in mobile phones).
Level of the private VR HMD
Response to the question 'Which kind of virtual reality platform do you have?'. It was treated as an ordinal and categorical variable with three possible options: mobile phone, video game console and personal computer.
Number of years using VR
Response to the question 'How long have you been using virtual reality?'. It was treated as an ordinal categorical variable with four options: less than 1 year, 1-2 years, 2-3 years and more than 3 years.
Usage frequency
Response to the question 'How often do you use virtual reality?'. It was treated as an ordinal categorical variable with four options (Just occasionally, Once a week, Several times a week, and one or more daily hours).
VR Usage for educational purposes

Response to the question 'In which of the following purposes do you tend to use virtual reality more?'. It was treated as a dichotomous variable (YES, if the participant uses VR for learning and gaining knowledge, and NO, otherwise).
Interest in VR for educational purposes
Response to the question 'Which of the following leisure genres regarding virtual reality are of your interest?'. It was treated as a Y/N dichotomous variable (YES, if the participant is interested in its educational potential, and NO, otherwise).
Optimism regarding the future pedagogical possibilities of virtual reality
Response to the question 'For which of the following purposes would you like to use virtual reality in the future?'. It was treated as a Y/N dichotomous variable (YES, if the participant sees her/himself in the future learning with this technology, and NO, otherwise).
Optimism regarding the future pedagogical possibilities of virtual reality
Response to the question 'In which areas do you forecast the future of virtual reality?'. It was treated as a Y/N dichotomous variable (YES, if the participant believes that VR will play a major role in the educational field in the next years and NO, otherwise).
QUANTITATIVE VARIABLES
Age
Number of years old as an interval scale variable.

Levels	Frequency	Percentage
Man	96	82.1
Woman	21	17.9
Primary	3	2.6
Secondary	39	33.3
University	49	41.9
Postgraduate	26	22.2
None	90	76.9
Teacher or student	27	23.1
No	21	17.9
Yes	96	82.1
Mobile phone	26	22.2
Video game console	54	46.2
Computer	37	31.6
Less than one year	72	61.5
Between one and two years	35	29.9
Between two and three years	4	3.4
More than three years	6	5.1
Occasionally	43	36.8
Once a week	25	21.4
Several times a week	40	34.2
One or more hours each day	9	7.7

No	101	86.3
Yes	16	13.7

No	84	71.8
Yes	33	28.2

No	57	48.7
Yes	60	51.3

No	62	53.0
Yes	55	47.0
TOTAL	**117**	**100.0**

	Mean	**Standard Deviation**
	36.91	6.39

Table 2

Variables	Sum of squares
Gender	13,418
Educational qualification	165,879
Current direct relationship with formal education	20,616
Previous experiences with sophisticated VR HMD	27,568
Level of the private VR HMD	161,535
Number of years using VR	169,738
Usage frequency	57,568
VR Usage for educational purposes	51,353
Interest in VR for educational purposes	33,517
Interest in the use of VR in formal education in the future	4,044
Optimism regarding the future pedagogical possibilities of VR	189,408

df	Root mean square	F	p-value
1	13,418	.327	.569
3	55,293	1,367	.256
1	20,616	.503	.480
1	27,568	.673	.414
2	80,768	2,013	.138
3	56,579	1,400	.246
3	19,189	.464	.708
1	51,353	1,261	.264
1	33,517	.820	.367
1	4,044	.098	.754
1	189,408	4,792	.031*

Table 3

	Gender	EQ	CRFE	PEV	LPV	YUV
Gender	-	14.55** .3**	12.38** .32**	20.6** -.42**	30.29** -.17	10.06* -.083
EQ	14.55** .3**	-	15.32** .3**	6.70 -.17*	13.63* -.17	15.37 -.02
CRFE	12.38** .32**	15.32** .3**	-	12.38** -.32**	22.57** -.31**	5.11 -.06
PEV	20.60** -.42**	6.7 -.17*	12.38** -.32**	-	59.88** .47**	1.56 .0.8
LPV	30.29** -.17	13.62* -.17	22.57** -.31**	59.88** .47**	-	12.02 .05
YUV	10.06* -.08	15.37 -.02	5.11 -.06	1.56 .0.76	12.02 .05	-
UF	27.1** -.35**	17.45* -.26**	8.04* -.18*	17.82** .28**	31.92** .3**	23.39** .16
UEP	18.46** .39**	3.62 .14	4.46* .19	4.81* -.20	19.07** -.09	18.18** .05
IEP	1.24 .1	.25 .0.3	1.35 .11	.33 -.05	2.35 -.05	6.3 .09
IUF	.35 .05	3.99 .1	.14 -.03	.01 -.01	.64 -.03	2.88 -.08
OFP	.18 -.04	3.2 .11	.02 .0.12	.82 .08	2.06 .11	5.25 .18*

UF	UEP	IEP	IUF	OFP
27.1**	18.463**	1.24	.352	.177
-.35**	.395**	.1	.053	-.038
17.45*	3.62	.25	3.99	3.2
-.26**	.14	.03	.1	.11
8.04*	4.46*	1.35	.138	.018
-.18*	.19	.11	-.03	.0.12
17.82**	4.81*	.33	.012	.82
.28**	-.2	-.05	-.01	.08
31.92**	19.07**	2.35	.64	2.06
.3**	-.09	-.05	-.03	.11
23.39**	18.18**	6.35	2.88	5.25
.16	.05	.09	-.081	.179*
-	2.98	3.44	7,296	2,957
	-.04	.13	-.044	.142
2.98	-	32.18**	4.17*	3.52
-.043		.51**	.18*	.16
3.43	32.18**	-	11.02**	5.1*
.13	.51**		.31**	.21*
7.3	4.17*	11.02**	-	10.62**
-.04	.18*	.31**		.3**
2.96	3.52	5.1*	10.62**	-
.14	.16	.29*	.3**	

Name of Material/ Equipment	Company	Catalog Number
Encuestafacil.com Saas (Software as a Service)	Encuestafacil.com	2019
Statistical Package for the Social Sciences (SPSS)	IBM	24
VR Forum in Elotrolado.net online portal	New EOL, S.L.	2019

Comments/Description
Software as a Service in the Encuestafacil.com private data server
Software package used in statistical analysis of data
The elotrolado.net is a Spanish website for communication and information technologies, digital leisure and video games, with more than 460,000 users and ten million of monthly visits. So far, it is the only Spanish website with a specific VR forum with more than 400 threads. Around 76,000 early VR adopters contribute with messages and posts talking about all HMD, and platforms on the market.

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Madrid, 10th September 2019

Dear Editor,

First of all, I would like to thank you, for the dedication and time spent in our project. We can clearly see the professionalism and effort dedicated to the review, so we are very happy with how we have been treated by the whole team of '*JoVE: Journal of Visualized Experiments*'.

The recommended suggestions of the editor are fair and adequate, so we have done our best to meet all the changes requested and to justify all of our decisions made. In relation to these, below you can find a detailed description of them:

1. We have changed the title to make it more suitable to the scope of the journal, focusing on the research tool and the protocol.
2. We have revised the text with a proficient English speaker.
3. We have corrected the typos identified by the reviewer to make the text clearer and with no more errors.
4. We have improved table 1 including the bullet list as recommended.
5. We have expanded the file 'Table of Materials' including the VR Forum as recommended and deleting all the references to the brand.
6. We have included a sample draft of the questionnaire and the acceptance letter of the scientific committee as supplementary material. They have been also referenced in the text.
7. We have replaced the original attached questionnaire by an English version as suggested. We have also reference it in the text.
8. We have added the criteria followed by the external experts to validate the draft questionnaire.
9. We have included specific variables examples in the places where the edited suggested so.
10. We have revised the references affected by these changes making the necessary adjustments.

In the following pages, you can find all the changes to the manuscript in **red**.

Faithfully yours,
Roberto Sánchez-Cabrero, PhD., Corresponding Author.

TITLE:

An online explorative study on the learning uses of virtual reality among early adopters

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KEYWORDS:

Virtual reality; ICT; early adopters; education; e-learning; learning tools

SUMMARY:

This article describes the profile of Spanish early adopters of virtual reality and their interests and preferences regarding learning and education applications of this technology. To this aim, we designed an online questionnaire and interviewed 117 users of the main virtual reality forum on the Internet.

ABSTRACT:

Virtual reality (VR hereafter) has shown great educational potential as it makes it possible to simulate any desired situation or event, thus playing an important role in addressing current educational challenges. Despite the unlimited learning possibilities that VR may offer, unless users are willing to apply virtual devices to education, the investment of time, money and effort will be fruitless. It is, therefore, crucial to assess the educational interest of the first generation of users of VR, and to identify their current needs. To this end, in this study we designed an online questionnaire and applied it through the SaaS (Software as a service) of a private server. The sample consisted of 117 early VR adopters recruited via a main portal of communication and information technologies in Spain. In order to engage participants, we posted a thread in the main forum, which is dedicated to the advances and potential uses of VR. Once the responses were gathered, we analyzed the relationship between twelve variables (mean contrasts with *Snedecor's F*, and contingency analysis with *chi-square* and *Sommer's d*). The results showed that the current profile of a VR user is a male over 35 years old, with university studies, and who has purchased his viewer recently (less than a year). As for the learning and teaching applications

that these users were interested in, only a 13.7% of the participants in this study use VR for educational purposes, although 28.2% were interested, indicating that perhaps the lack of apps or learning experiences may be hampering the use of VR within education. Almost half of the early adopters surveyed would like to learn using VR technology and are somehow optimistic about the relationship between VR and education, particularly those who are younger.

INTRODUCTION:

Information and communication technologies are evolving rapidly to make it easier for human beings to communicate and relate to each other. Thanks to this, the distance and time that someone needs to contact and interact with someone else is reduced. However, this connection, when made through technology, is still much poorer and limited than face-to-face contact[1].

Virtual reality (VR hereafter) enjoys a major advance in simulating physical experiences, allowing us to interact within a computer environment that feels real giving us a sense of *'being there'* and closeness. This is one of the main reasons why VR occupies a privileged place in the plans of technology development of the main companies. However, if they want to meet the needs of their potential customers, research on VR is essential to accomplish this goal[2].

In Spain, as in most of Western societies, the emergence of the first commercial head-mounted displays (HMD hereafter), capable of providing acceptable immersion experiences[3], increased the interest in VR, leading to the development of software and VR experiences. For instance, some of the most important VR studies are currently Spanish, such as Vertical Robot, multi-awarded for its products[4], or the Tessera Studios and Dual Mirror Games, all of them of international prestige. Let us not forget the educational and scientific spheres, which have experienced a whole explosion of research and applied educational experiences from 2015 onwards, as shown in the review by Aznar-Díaz, Romero-Rodríguez and Rodríguez-García[5].

Most universities are already aware of the crucial role that VR will play, not only in the business and industry sector, but also in many scientific disciplines. And, therefore, they are working on several research and innovation lines. For example, the Alfonso X el Sabio University is a pioneer worldwide in the use of VR simulation and augmented reality for training future doctors at the *'UAX Virtual Simulation Hospital'*, unique in the world. Furthermore, this university applies VR in social, psychological and educational research[6.]

Since the popularization of the Internet a few decades ago, different educational methodologies have evolved towards the so-called e-learning that a growing number of universities are adopting[7,8]. This online learning system is aimed at developing distance learning through technological means, some of which were developed specifically for it, whilst others were incorporated and adapted for educational purposes. However, e-learning is not exempt from limitations when it comes to social interaction. In this sense, VR considerably reduces some of these shortcomings, making interaction between people easier and much more realistic than any other technology. Also, it takes advantage of all the possibilities that technology offers us, creating an almost infinite world of opportunities[3]. For instance, VR allow us to travel through the universe, or along the seabed, to see dinosaurs, to observe the microscopic world or even to

live emotions associated with certain experiences and social events in a simulated way. Therefore, VR could be a vital educational resource, helping teachers in their struggle to engage students with classroom topics [9-11].

However, not every aspect is positive, and some downsides must be considered. As mentioned above, it would be useless to develop new and educational applications of VR if the potential trainees and students were not willing to use it or preferred other forms of e-learning, which could be narrower yet more aligned with their true interests and preferences. This is why the desired relationship between VR and learning not only depends on a world of exciting possibilities, but, more importantly, on building this relationship upon real social needs and demands. We must bear in mind that VR has been targeted by companies not so long ago, and that the percentage of the worldwide population that has used VR is less than 1% of the total. VR is also a technology that is still in its infancy and that cannot be understood if someone has not used it. Precisely, this last point explain why VR is surrounded by so many prejudices that result either from ignorance or from the social fear of what is new[12,13].

To bridge this gap between potential uses of VR and actual demands, it is necessary to ask the early adopters, as they purchase HMD as soon as they are available in the market. These users are so powerfully attracted to technological innovations that they don't fear purchasing new products, which may succeed or fail commercially. Therefore, the uncertainty that surrounds these new products does not affect them as it happens in the rest of the population and, for this reason, they are the first to discover the real possibilities of VR technology not yet established in the market. Consequently, they can provide information at a real user level making them a valuable source for this study.

As a sampling method, we designed an online examination questionnaire that was filled out by a representative convenience sample of early adopters. Participants were recruited from a VR forum in a Spanish portal for communication and information technologies, digital leisure and video games with more than 460,000 users and ten million monthly visits[14] (see table of materials). We created a thread that received 2,000 visits in less than two months. The participants who accessed the questionnaire through the hyperlink responded online to all the questions raised.

So far, in Spain this is the only website with a specific VR forum and more than 400 threads. Around 76,000 early VR adopters contribute with messages and posts talking about all HMD, and platforms on the market[15]. For this reason, it is the best place to locate a homogeneous convenience sample of early VR adopters. According to Jager, Putnick, and Bornstein[16], when a subgroup is homogeneous on one or more sociodemographic factors, we can estimate results with clearer generalizability, providing more accurate accounts of population effects and subpopulation differences. It also eliminates possible biases common in heterogenous convenience sampling.

Our research goals were: (1) to study the profile of early adopters (2) to examine the current state of VR as an educational technology, determining its degree of implementation; (3) to assess the acceptance of VR as a learning tool among early adopters.

PROTOCOL:

The protocol was submitted to the *Scientific and Ethical Committee of the Nebrija University*, in which a group of external experts reviewed and validated the process. To be able to participate in the study, we required a written acceptance informed consent as recommended by the Declaration of Helsinki[17], and it was made clear to the participants that they were not going to be involved in any experimental condition.

1. Design of the research instrument

1.1. Design a first draft of the questionnaire to meet the goals of the study (see a sample draft of the questionnaire in the supplemental files).

NOTE: the aforementioned draft is created with Microsoft Word so it can be easily shared and modified. Questions included single, multiple and open answers that were grouped in different thematic pages:

- Page 1: Accept a written informed consent obligatorily.
- Page 2: Demographic and social data of participants.
- Page 3: Descriptive information of previous VR experience as well as frequency of usage.
- Page 4: Subjective opinions and attitudes regarding VR.
- Page 5: Beliefs about the future of VR in education[3].

1.2. Send a draft to three social scientists and experts in technology, who were external to the research team. The task of this committee is to review the experimental design: ethical aspects and study design according to scientific guidelines. Also, they must validate the tool, considering aspects such as item comprehension (both questions and possible answers) in relation to the research goals.

1.3. Design a definitive version of the questionnaire, taking into account the suggestions made by the group of experts, so it can be submitted to a scientific an ethical committee along with a research report of the project.

NOTE: We obtained a positive evaluation both in the scientific and ethical areas of the Nebrija University committee (see the positive evaluation of the Nebrija University committee in supplemental files). Also, there was a follow-up of the entire research process conducted by the same committee.

2. **Adapt the questionnaire to the online specification of a secure server.**

2.1. Go to main page of the software as a service (SaaS hereafter) with a private server (see table of materials) as a registered user of the platform (a registration process that must be done

previously by completing the personal data) and select **Create your survey from scratch** (See Fig. 1).

[Place **Figure 1** here]

2.2. Create several pages of the questionnaire with the questions, as well as with possible answers through the SaaS with a private server. In this step it is important to follow the recommendations received during the validation process by the group of experts. Also, in the instructions to the participants, explain correctly the question posed and the type of answer (open, closed, one or multiple-choice, etc.,) that must be filled out (See Fig. 2).

[Place **Figure 2** here]

2.3. Once the survey is created and saved (see the final questionnaire in the supplemental files), return to the main menu of the platform, select the questionnaire and click on the icon **open/close public survey** to make it available to participants. After that, click on the icon **obtain a link to the survey** choosing one of several options by which participants will access to the survey: a link embedded in an email or in a web, an iframe in a website, a pop up in a web, a link to computers of a call center, etc. (See Fig. 3).

[Place **Figure 3** here]

NOTE: The criterion to develop the final tool were that the questionnaire had to be completed with any electronic device with Internet access (tablets, Personal Computers, Smartphones, etc.); participants had to fill out the questionnaire just one time (to this end, the chosen system must be able to keep the information of users who have already participated by identifying the IP of the device that was used to access and complete the survey); also the selected system had to guarantee the anonymity of the participants at all times, allowing the data to be stored on a secure private server.

3. Sampling method

3.1. Go to the Internet portal as a registered user (registration that must be done before completing all the personal data) and create a thread in the VR forum to detail the study (see table of materials). Post a hyperlink to the survey hosted in the online private server (See Fig. 4).

[Place **Figure 4** here]

3.2. Go to main page of the SaaS as a registered user of the platform, select the questionnaire created and click on **Results**. On the pop-up menu, click on the icon **questionnaire** to access directly to the filled-out questionnaires. Eliminate all the incomplete or erroneous questionnaires through the SaaS (See Fig. 5).

[Place **Figure 5** here]

3.3. Once the questionnaires reach the minimum number of participants (>100), including those incomplete questionnaires excluded, go to main page of the SaaS as a registered user of the platform, select the questionnaire and click on the icon **open/close public survey** to finish the survey, so no one else can participate again (See step 1 in Fig. 3 again).

NOTE: The participants of this study are 117 VR users (21 females and 96 males) who owed a VR HMD (any available in Spain). It is worth saying that the final sample of 117 participants resulted from a screening and filtering 578 questionnaires, of which we excluded many undelivered cases, as well as 36 questionnaires that were incomplete, without applying any other filter to the data. As for the mean age of the participants, this was μ=36.91 years old with a standard deviation of σX=6.39 (μ=36.19 and σ_X=7.50 for females and μ=37.07 and σ_X=6.15 for males).

4. Statistical analyses

4.1. Go to main page of the SaaS as a registered user of the platform, select the survey created and click on the icon **Results**. On the pop-up menu, click on **Export** and select the pop-up options of the report detailed (Advanced spreadsheet format), in **text** and with .csv extension (See Fig. 6). Once the questionnaires are completed by the participants, export them to an email account in *.csv* format, so these can be kept in a save, private and protected place.

[Place **Figure 6** here]

4.2. Open the statistical software (see table of materials) and select **File** menu > **Import data** > **CSV Data**. Select the file .csv previously saved. This process allows us to transform the anonymous data into the analysis format that requires the statistical software package (See Fig. 7).

[Place **Figure 7** here]

4.3. Select the variables to analyze statistically ('Gender', 'Age', 'Educational qualification', 'Current direct relationship with formal education', 'Previous experiences with sophisticated VR HMD', 'Level of the private VR HMD', 'Number of years using VR', 'Usage frequency', 'VR Usage for educational purposes', 'Interest in VR for educational purposes', 'Optimism regarding the future pedagogical possibilities of virtual reality' and 'Optimism regarding the future pedagogical possibilities of virtual reality') and delete the rest of information imported by the .sav file generated by the statistical software package.

4.4. Assess the internal consistency of the questionnaire with the **Alpha's Cronbach** with the statistical software package. To this end, select '**Analyze**' menu > **Scale** > **Reliability Analysis**, and transfer all the variables to the **Reliability Analysis** dialogue box. Finally, click on the **OK** icon to generate the desired output (See Fig. 8).

[Place **Figure 8** here]

NOTE: The questionnaire had a high reliability and internal consistency, measured through the *Alpha's Cronbach* (α=0.826).

4.5. Carry out the descriptive analysis with the statistical software package. Explore descriptive statistics such as the arithmetic mean, and the standard deviation for the quantitative variable **Age**. Study frequency distribution in the rest of variables. To carry this analysis out, select **Analyze** menu > **Descriptive Statistics** > **Frequencies** and, after the output, **Analyze** > **Descriptive Statistics** > **Descriptive** (See Fig. 9).

[Place **Figure 9** here]

4.6. Conduct *One-Way ANOVA* analysis with the statistical software package. To this end, select **Analyze** menu **> Compare Means > One-Way ANOVA**, and in **One-Way ANOVA** dialogue box put **Age** as dependent variable and the rest of variables as factors (See Fig. 10). This process should be done for each of the nominal ('Gender', Current direct relationship with formal education', 'Previous experiences with sophisticated VR HMD', 'VR Usage for educational purposes', 'Interest in VR for educational purposes', 'Optimism regarding the future pedagogical possibilities of virtual reality' and 'Optimism regarding the future pedagogical possibilities of virtual reality')and ordinal variables ('Educational qualification', 'Level of the private VR HMD', 'Number of years using VR' and 'Usage frequency'). The output shows statistical significance of *`Age'* as a discrete quantitative variable by comparing means with the *Snedecor's F* distribution (non-considering equality of variances).

[Place **Figure 10** here]

4.7. Conduct *Chi-squared test* on contingency tables to test whether or not there is a relationship between the variables, and *Somers' d* to reflect strength and direction of the associations. To this end, go to **Analyze menu > Descriptive Statistics > Crosstabs** and, in the Crosstabs dialogue box, click on **Statistics** and select options **Chi-squared** and **Somers' d** and click on **continue** (See Fig. 11).

4.8. In the **Crosstabs** dialogue box transfer one of the nominal or ordinal variables as rows and the rest as columns. This process must be repeated for each of the variables in the rows, eliminating the ones already analyzed, to obtain all the correlations between them.

[Place **Figure 11** here]

REPRESENTATIVE RESULTS:

Table 1 presents the frequency distribution of the categorical variables (nominal, dichotomous and ordinal variables) along with the mean and standard deviation of the interval scale variable 'Age'.

[Place **Table 1** here]

Results at first glance give us a profile of users that is showed in Table 1: males (82.1%), with university studies (64.1% postgraduates), related to education (76.9%), having previous experience with VR HMD (82.1%), who acquired a viewer during the last year (61.5%); as for the use of this technology, they are players of video game consoles VR HMD (46.2%), who use VR at least once a week (63.2%), but not for learning purposes (86.3%) and who don't seem to be interested in using this technology for learning (71.8%), although they do show interest in using it for educational purposes in the future (51.3%) and despite the fact that they are not very optimistic about its future pedagogical possibilities (47%)[6]. Regarding the age of participants, we can see in fig. 12 that the mean was μ=36.91 with a standard deviation of σ_X=6.39.

There are not any statistically significant age and gender differences, as observed in Table 2. Only 'Optimism regarding the future pedagogical possibilities of VR' varies significantly with 'age': Those who feel more optimistic about the future are youngest (μ=35.56 and σ_X=5.74) than those who do not feel that way (μ=38.11 and σ_X=6.74)[9].

[Place **Figure 12** here]
[Place **Table 2** here]

Table 3 reports the values of the contingency tables using the *Chi-squared* test and the *Somers' d*, showing if the correlations observed are significant and the direction of them (positive or negative).

[Place **Table 3** here]

Notice that a number of nominal variables were recoded and given ordinal values to make them ordinal. This was done to see the relationship between gender (male/female) and these variables. In other words, the integer given to each condition does not transform the variable into a quantitative one, but simply serves to know instantly the trend shown by the results towards one or another condition. Otherwise it would be impossible to establish if being a man or a woman was directly or indirectly associated with the rest of the variables. A similar process was done with every binary variable, giving the higher score to the category 'YES'[9].

The *Chi-squared test* and *Somers' d* run on the contingency table outline the relationship that exists between some variables. For instance, females are educated at a higher level, a superior number of women are also related to the field of formal education, and more females report using VR for learning purposes too. As for males, they use VR more frequently, and have tried the sophisticated VR HMDs.

A positive and significant relationship between formal education and the level of studies was found, as well as a significant and negative association between having tried a sophisticated VR HMD, viewer devices owned and the frequency of VR usage. It was clear that the frequency of usage is significantly and directly associated to having tried a sophisticated VR HMD and to viewer devices owned. The same variable is significantly and inversely associated to the educational

qualification of the VR user. There is also a significant, strong and direct relationship between having tried a sophisticated VR HMD and viewer devices owned [9].

As for the variables that were directly related to the usage and inclinations for VR as a learning tool, we can see a strong and positive correlation, since a 'Yes' answer to having an interest in the usage of VR as a learning tool, is significantly and directly associated to learning through VR in formal education. They are also associated with currently using VR as a learning tool and being optimistic about future educational possibilities of VR[9].

The contingency table also show a statistically significant and nonlinear (or second-degree) association with the *Chi-squared* analyses but not with *Somers' d*. This situation is due to some of the categories of a variable having a partial influence over another variable, such as 'Number of years using VR'. As for the variables that assess which users had used VR recently, results show that the interest in VR is still developing. More specifically, we can see that the usage frequency is high, but interest or preferences change depending on the willingness to try all the VR possibilities.

As for the 'VR HMD devices owned' we can see gender differences in 'Video game console' (see Fig. 2), and in 'Current use of VR as a learning tool' (see Fig. 3). Among users of game consoles VR HMD (e.g, Sony PSVR) there were no women, and they were not interested in the use of the VR as a learning tool. This points to a strong gender difference in entertainment and leisure[9].

[Place **Figure 13** here]
[Place **Figure 14** here]

FIGURE AND TABLE LEGENDS:

Figure 1: How to start creating the questionnaire from scratch. (1) Click on 'New Survey' icon. (2) Select *'create your survey from scratch'*.
Figure 2: How to design the questionnaire. (1) Edit the survey. (2) Add and configure pages and questions. (3-5) Develop pages, questions and answers.
Figure 3: How to obtain a link to the survey. (1) Open the survey. (2) click on 'obtain a link to the survey' icon. (3) Select the chosen method.
Figure 4: How to launch a thread in the VR forum. (1) Click on *'Sistemas VR'* icon. (2) click on 'NUEVO HILO' icon. (3,4) Write a post with the questionnaire link included.
Figure 5: How to eliminate all the incomplete or erroneous questionnaires. (1) Click on *'Results'* icon. (2) click on *'Export'* icon. (3) Eliminate all the incomplete or erroneous questionnaires.
Figure 6: How to export data to use in the statistical software package. (1) Click on *'Results'* icon. (2) click on *'Questionnaires'* icon. (3) Select 'text' and 'csv' in 'detailed' option.
Figure 7: How to import data in the statistical software package. Select 'File' menu > Import data > CSV Data.
Figure 8: How to assess the internal consistency of the questionnaire. Select 'Analyze' menu > Scale > Reliability Analysis.

Figure 9: How to carry out the descriptive analysis of the data. Select 'Analyze' menu > Descriptive Statistics > Frequencies and, after the output, 'Analyze' > Descriptive Statistics > Descriptive.

Figure 10: How to conduct One-Way ANOVA analysis. Select 'Analyze' menu > Compare Means > One-Way ANOVA.

Figure 11: How to conduct *Chi-squared* and *Somers' d* test. (1) Select 'Analyze' menu > Descriptive Statistics > Crosstabs. (2) select 'Chi-squared' and 'Somers' d' options.

Table 1: Frequency distribution of the variables considered in the study.
This table has been modified from Sánchez-Cabrero et al.[9]

Figure 12: Age and gender pyramid.
This figure has been republished from Sánchez-Cabrero et al.[9]

Table 2: Age comparison of means over the rest of the variables through ANOVA test. (df) Degrees of Freedom. (F) Snedecor's F. (p-value) probability value or significance. * Comparison of means is significant at the level of 0.05.
This table has been modified from Sánchez-Cabrero et al.[9]

Table 3: Contingency table using the chi-squared test (first value in each cell) and Somers' d (second value in each cell). (EQ) Educational qualification. (CRFE) Current direct relationship with formal education. (PEV) Previous experiences with sophisticated VR HMDs. (LPV) Level of the private VR HMD. (YUV) Number of years using VR. (UF) Usage frequency. (UEP) VR Usage for educational purposes. (IEP) Interest in VR for educational purposes. (IUF) Interest in the use of VR in formal education in the future. (OFP) Optimism regarding the future pedagogical possibilities of VR. * Correlation is significant at the level of 0.05. ** Correlation is significant at the level of 0.01.
This table has been modified from Sánchez-Cabrero et al.[9]

Figure 13: VR HMD devices owned and gender. (Green) Woman (Blue) Man.
This figure has been republished from Sánchez-Cabrero et al.[9]

Figure 14: VR HMD devices owned and current use. (Green) Current use of virtual reality as a learning tool (Blue) Not Current use of virtual reality as a learning tool.
This figure has been republished from Sánchez-Cabrero et al.[9]

DISCUSSION:

This study explores the profile of Spanish early adopters of VR, assessing their interest in the use of this VR as a learning tool. Therefore, along with other studies, it offers a fresh perspective on the real possibilities of VR and its applications to the classroom[9].

The users of VR devices live literally everywhere, so there is not a physical place to identify and locate them. For this reason, the only possible way to find them is through VR forum and websites that VR users visit to find out information. In conclusion, not only did we need to use the virtual space to survey VR users, but it was also mandatory to proceed with an online questionnaire.

Finding the sample was complex because the first VR HMDs have been on the market for less than three years. It is worth mentioning that we should not mistake the consolidation of technology for its popularity: VR may be fairly popular despite most people having never tried it. This narrowed the population and sample to be studied. Finding VR users was another difficulty

to overcome, since they form a heterogeneous group with different interests and socio-demographic characteristics, who are hard to reach and locate. Also, they use different VR head-mounted displays (PlayStation VR: PSVR, Oculus Rift, HTC Vive, Windows Mixed Reality: WMR, etc.) and platforms (Personal computers, Sony PlayStation 4, smartphones, etc.)[9] which makes it even harder to find them.

An online questionnaire was the only possible way to examine early VR adopters' preferences and interests in the use as a learning tool, because the dispersion of users in different locations and systems makes any face-to-face consultation or any other methodology common in the social sciences, such as interviews or focus groups, impossible. However, this method is not without limitations, since the participants' answers were constraint to the questions, most of which were structured.

In addition to this, the real number of Spanish VR early adopters is difficult to know because most manufacturers do not make public the information about their sales for fear of discouraging potential investors or clients. Nonetheless, we can estimate this number if we have a look at indirect sources. For instance, in 2018 less than 4 million VR HMDs were sold on the worldwide market[18], which makes users of these technological applications, software and video games less than 1% of the total population[19], i.e. a 42% of the worldwide population approximately[20]. Therefore, with the data in hand, just less than 5 per thousand of the population can be regarded as early adopters.

One of the main implications of this study lies in the relationship between the educational field and VR, which is living a critical moment[21]. VR technology is now taking its first commercial steps, a fact that explains why efforts are currently directed at entertainment and leisure [18,19]. The results of this study show that users' interest in entertainment is much greater in VR HMDs than in video consoles (PSVR). Also, this interest is stronger in males who use their laptops or computers more frequently. As for the early adopters, learning is not a priority for them, and those who are interested find themselves with very few VR options. This can be seen, for instance, in the *Oculus Store* that has a very reduced supply of VR educational applications[22]. Yet, its current usage is far from being insignificant, as a 13.7% of use tell us that the number of customers is not insignificant

According to some indicators analyzed by the *IDC Corporate USA*[21], the sales of VR devices has increased 27,2% during the first quartile of 2019 compared to the same period of 2018. And this has occurred despite the fact that it was believed that the sector hadstagnated. This shows how the industry of VR is growing at an even faster rate than expected. And this is surely due to the existence of new viewers such as the Standalone VR HMD *Oculus Quest that was launched to the market by the beginning of* 2019.

Our results also indicate that interest in using VR for educational purposes is much higher than its actual use. Also, half of the users felt optimistic when asked about the educational possibilities of VR. This, along with the fact that VR is still landing in this field despite conditions are not being yet the best, may be taken as a positive fact. This conclusion is similar to that of Yildirim's[11] or

Fernández-Robles[10], who also found that students were interested in the use of VR as an educational tool. According to our results it can be concluded that the lack of VR educational applications may be impeding advances and affecting somehow the interest of potential users. Consequently, the future of the relationship between education and VR may depend on the growth and evolution of new applications within this field. Without them, we run the risk of wasting a golden opportunity.

However, how this relationship between education and virtual reality will progress in the future depends on the apps development and on the evolution of this sector. Our results show that, on the one hand, the lack of apps may hinder the interest of users. And, on the other hand, without the apps, these first green shoots could wither quickly.

VR accessibility is another major issue, since most teachers who participated in this study showed a preference for low-cost kits and reported a sporadic use. Perhaps, if costs were reduced, professionals in the educational field would go for better equipment and would also increase the time of use, which, in turn, could change their minds about VR as a learning tool[9]. However, given that VR is just emerging within education, it may be too soon to make any conclusive statements. Consequently, we must wait for the consolidation of this technology if we are to make more accurate evaluations of its virtues, potentials and shortcomings.

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The authors are very thankful to the managing team of *Elotrolado.net*, because without their help this study would have been impossible to conduct. We are also grateful to *Encuestafacil.com*, which offered us their services free of charge so that we could create the questionnaire and use their servers to gather the data. Finally, we appreciate the feedback and support received from the Scientific and Ethical Committee of the Nebrija University and from Alfonso X el Sabio University.

DISCLOSURES:
The authors have nothing to disclose.

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SAMPLE DRAFT

Research goals:

1. To study the profile of early adopters (page 2).
2. to examine the current state of VR as an educational technology, determining its degree of implementation (Page 2 and 3)
3. to assess the acceptance of VR as a learning tool among early adopters (Page 3, 4 and 5).

PAGE 1- ACCEPT A WRITTEN INFORMED CONSENT OBLIGATORILY

We inform you that the personal data collected in this document, as well as those that you provide in the future, either derive from the development of the service in charge or are generated as a result of the data processing, all of them necessary to be able to provide our services, will be incorporated into a Mixed file, owned by the Nebrija University, Calle de Sta. Cruz de Marcenado, 27, 28015 Madrid, authorizing it to process them automatically or not, as well as the transfer in favor of persons dedicated to the analogue purpose, for its use in relation to the development of its activity consisting of research and dissemination of its results, including the sending of information about our services or activities.

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*1. After reading the above, I DECLARE that I have been adequately informed of the details of the study in which I will participate voluntarily, and that I have had the possibility to answer any questions regarding the study.

I agree (*COMPULSORY)

PAGE 2- DEMOGRAPHIC AND SOCIAL DATA OF PARTICIPANTS

Describe your personal information (anonymous information) in the following sections.

2. Age

Choose one (18-80)

3. Gender

Male

Female

4. Nationality

    Spanish

    Other

5. Place of residence

6. Education level

7. Profession

    Student

    Teacher

    Other

8. Current occupation

    Student

    Unemployed

    Self-employed

    Hired hand

    Businessperson

    Civil servant

9. Virtual reality platform

    Oculus Rift

    HTC Vive

    PSVR

    WMR

    Mobile platforms

10. Which kind of virtual reality platforms have you try?

    Oculus Rift

    HTC Vive

    PSVR

    WMR

    Mobile platforms

11. Which kind of virtual reality platform do you have?

    Oculus Rift

    HTC Vive

PSVR

WMR

Mobile platforms

12. Which is your favourite virtual reality platform?

Oculus Rift

HTC Vive

PSVR

WMR

Mobile platforms

PAGE 3. DESCRIPTIVE INFORMATION OF PREVIOUS VR EXPERIENCE AS WELL AS FREQUENCY OF USAGE

Now you have to describe how and when do you make use of virtual reality.

13. How long have you been using virtual reality?

Less than a year

More than a year

1 to 2 years

2 to 3 years

More than 3 years

14. How often do you use virtual reality?

Once or twice a day

Several times a week

Once a week

Occasionally

15. In which of the following areas do you tend to use virtual reality more?

Videogames

Video

Experiences

Professional training / education

Therapeutic purposes

Sports training

Work purposes

16. Which of the following leisure genres are of your interest regarding virtual reality?

Films and documentaries

Experiences

Education purposes

Sightseeing

Speed simulators

Flight simulators

Escape rooms

Role games

Shooters

Adventure games

Horror games

Sports training

Games for kids

Graphic design games

Other, please specify

4- SUBJECTIVE OPINIONS AND ATTITUDES REGARDING VR

Reflect and give your opinion about the way you will use virtual reality in the future and its degree of social acceptance.

17. For which of the following purposes would you like to use virtual reality in the future?

Workplace

Professional training / education

Entertainment

Online social relations

Alternative therapies

Sports training

Sightseeing

Other, please specify

18. In which areas do you forecast the future of virtual reality?

Information technology

Teaching resource

Entertainment

Communication

Psychology

Science

Advertising

Tourism

Sports training

Other, please specify

19. Which sort of restrictions may prevent the spread of virtual reality from happening in today's society?

Price

Technology gap

Lack of awareness of its potential

Bias against technology

Home storage

Lack of proper computer equipment

Other, please specify

PAGE 5- BELIEFS ABOUT THE FUTURE OF VR IN EDUCATION

Think and give your particular opinion on virtual reality.

20. According to your opinion, which kind of shortcomings does virtual reality have at present?

21. In your view, how important is virtual reality in the realm of new information technologies?

22. According to your opinion, how important is virtual reality in society?

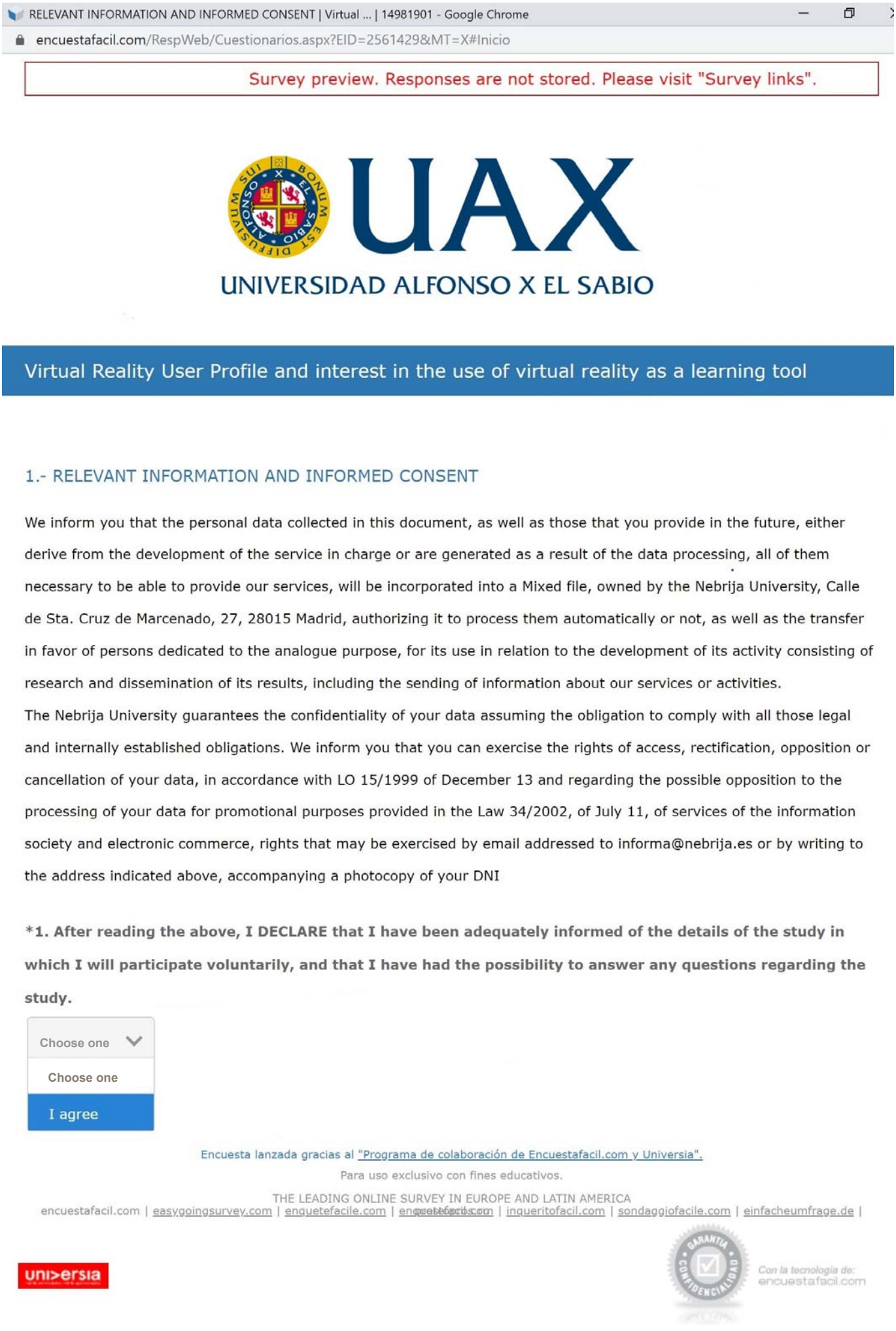
23. Which kind of educational value can virtual reality have in the future?

24. Which kind of professional value can virtual reality have in the future?

25. What does the future hold for virtual reality?

26. Which kind of impact can virtual reality have on emotional or psychological aspects?

27. Do you consider it possible the use of virtual reality in therapeutic interventions? If so, what type(s)?



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UAX

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Virtual Reality User Profile and interest in the use of virtual reality as a learning tool

1.- RELEVANT INFORMATION AND INFORMED CONSENT

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***1. After reading the above, I DECLARE that I have been adequately informed of the details of the study in which I will participate voluntarily, and that I have had the possibility to answer any questions regarding the study.**

Choose one

Choose one

I agree

2.- PERSONAL DEMOGRAPHIC INFORMATION

Describe your personal information (anonymous information) in the following sections.

***2. Age**

Choose one

***3. Gender**

Male Female

***4. Nationality**

Española Other

5. Place of residence

0/4000

***6. Education level**

Elementary Secundary Universitary Postgrade

***7. Profession**

Student Teacher Other

***8. Current occupation**

Student Hired hand
Unemployed Businessperson
Self-employed Civil servant

***9. Virtual reality access platform**

Oculus Rift HTC Vive PSVR WMR Mobile platforms (smartphone, Oculus Go, Oculus Quest)

***10. Which kind of virtual reality platforms have you try?**

Oculus Rift HTC Vive PSVR WMR Mobile platforms (smartphone, Oculus Go, Oculus Quest)

***11. Which kind of virtual reality platform do you have?**

Oculus Rift HTC Vive PSVR WMR Mobile platforms (smartphone, Oculus Go, Oculus Quest)

12. Which is your favourite virtual reality platform?

Oculus Rift HTC Vive PSVR WMR Mobile platforms (smartphone, Oculus Go, Oculus Quest)

3.- REGULAR USE OF VIRTUAL REALITY

Now you have to describe how and when do you make use of virtual reality.

***13. How long have you been using virtual reality?**

Choose one

***14. How often do you use virtual reality?**

Choose one

***15. In which of the following genres do you tend to use virtual reality more ?**

- [ ] Videogames
- [ ] Vídeo
- [ ] Experiences
- [ ] Professional training / education
- [ ] Therapeutic purposes
- [ ] Sports training
- [ ] Work purposes

16. Which of the following leisure genres are of your interest regarding virtual reality?

- [ ] Films and documentaries
- [ ] Experiences
- [ ] Education purposes
- [ ] Sightseeing
- [ ] Speed simulators
- [ ] Flight simulators
- [ ] Escape rooms
- [ ] Role Playing games
- [ ] Shooters
- [ ] Aventure games
- [ ] Horror games
- [ ] Sports training
- [ ] Games for kids
- [ ] Graphic design
- [ ] Other, please specify

4.- INTERESTS AND FUTURE OF VIRTUAL REALITY

Reflect and give your opinion about the way you will use virtual reality in the future and its degree of social acceptance.

17. For which of the following purposes would you like to use virtual reality in the future?

- [ ] Work tasks
- [ ] Professional training / education
- [ ] Entertainment
- [ ] Online social relations
- [ ] Alternative therapies
- [ ] Sports training
- [ ] Sightseeing
- [ ] Other, please specify

18. In which areas do you forecast the future of virtual reality?

- [ ] Information technology
- [ ] Teaching resource
- [ ] Entertainment
- [ ] Communication
- [ ] Psychology
- [ ] Science
- [ ] Advertising
- [ ] Tourism
- [ ] Sports training
- [ ] Other, please specify

19. Which sort of restrictions may prevent the spread of virtual reality from happening in today's society?

- [ ] Price
- [ ] Technology gap
- [ ] Lack of awareness of its potential
- [ ] Bias against technology
- [ ] Empy enough space at home
- [ ] Lack of proper computer equipment
- [ ] Other, please specify

5.- PERSONAL VIEWS AND THOUGHTS

Think and give your particular opinion on virtual reality.

20. According to your opinion, which kind of shortcomings does virtual reality have at present?

0/4000

21. In your view, how important is virtual reality in the realm of new information technologies?

0/4000

22. According to your opinion, how important is virtual reality in society?

0/4000

23. Which kind of educational value can virtual reality have in the future?

0/4000

24. Which kind of professional value can virtual reality have in the future ?

0/4000

25. What does the future hold for virtual reality?

0/4000

26. Which kind of impact can virtual reality have on emotional or psychological aspects?

0/4000

27. Do you consider it possible the use of virtual reality in therapeutic interventions? If so, what type(s)?

0/4000

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Comité de Ética y Calidad en Investigación – CECI

En Madrid, a 8 de febrero de 2018, el que subscribe, D. Jon Andoni Duñabeitia Landaburu, actuando en calidad de secretario del Comité de Ética y Calidad en Investigación – CECI de la Facultad de Lenguas y Educación de la Universidad Antonio de Nebrija,

CERTIFICA:

Que el día 7 de febrero de 2018, se celebró en el domicilio social de la Universidad una reunión extraordinaria del Comité de Ética y Calidad en Investigación – CECI, de conformidad con el Orden del día remitido a los miembros del mismo la semana anterior, con la asistencia de Dña. Susana Martín Leralta, en calidad de presidenta, Dña. Núria Camuñas Sánchez-Paulete y Dña. Anna Doquin de Saint Preux, en calidad de vocales y de D. Jon Andoni Duñabeitia Landaburu, en calidad de secretario, y que acordaron por unanimidad, entre otros, el siguiente acuerdo y recomendación:

- Emitir, a todos los efectos que corresponda, **INFORME VALORABLE** al proyecto de investigación titulado ***Estado actual de la adopción inicial de la realidad virtual en la sociedad española, perfil del usuario y potencial pedagógico*** que fue debidamente presentado por D. Roberto Sánchez Cabrero, y afirman que cumple con los requisitos científicos y éticos impuestos por la Facultad en cumplimiento de la normativa acordada en la Declaración de Helsinki.

Hasta aquí la transcripción del acuerdo del Comité de Ética y Calidad en Investigación – CECI, y que se certifica a los efectos oportunos con el visto bueno del secretario en representación de todos los miembros de dicho Comité.

VºBº

UNIVERSIDAD NEBRIJA

Jon Andoni Duñabeitia Landaburu
SECRETARIO