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Utilization of Virtual Reality for General Education Purposes

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Abstract
In a 23-question survey answered by 154 college students, we examine multiple-choice and free-form answers about the use of Virtual Reality (VR) using a statistical □2 analysis at the p=0.05 level. We find that males are more experienced with VR in general, have a greater interest in seeing VR implemented further, and are more committed to radical changes in educational methodology than females are (p=0.05). In addition, we find that Hispanics/Latinos, Black / African Americans, Pacific Islanders, and those of mixed race are more inclined to provide continual feedback as regards the implementation of VR in the school curriculum than (non-Hispanic) White and Asian people are (p=0.05). The Covid-19 pandemic is found to have had limited impact thus far in terms of VR use, but the interest in using VR in schools since then has generally increased quite a bit. Commitment to invest in VR and provide continual feedback varies quite a bit as well but is overall strong.

Keywords: Virtual Reality, Education, Demographics, Chi-Square Statistics

Introduction

The use of Virtual Reality in a variety of professional, military, governmental, and educational fields has continued to expand over the past several decades, and the recent Covid-19 pandemic has brought further attention to this field. VR technology can be traced back to Sir C. Wheatstone, who first described stereopsis in 1838. His research illustrated how when a subject is shown photographs taken from different points, the brain combines the two images, with the viewer thus experiencing a sense of three-dimensional (3D) depth and immersion (Barnard, 2019). Almost a full century later, in 1935, S. Weinbaum released a science fiction short story in which the main protagonist is outfitted with a pair of goggles that transport him to a fictional world that includes holographic and haptic feedback. A couple of decades later, the first actual VR 'machine' in the form of a large booth was created and patented by Sensorama cinematographer M. Heilig (*ibid*). This allowed a person to experience a stereoscopic 3D screen while sitting in a vibrating chair surrounded by stereo speakers and even scent producers (5D). The first head-mounted display (HMD), the 'Telesphere Mask' was patented in 1960 by M. Heilig, and provided stereoscopic 3D images in a wide vision format with sound. That was developed in 1961 by two Philco Co. engineers, with individual video screens for each eye and a head-tracking system. This HMD, 'Headsight', was developed for the military to allow for remote viewing of hazardous situations, helping pave the way for the first Air Force flight simulator in 1966. With substantial military funding, VR technology was fundamentally improved. In 1972, GE extended the HMD approach to flight simulators in mock cockpits, allowing for more realistic pilot training with a 180-degree field of vision (*ibid*).

Over the next several decades, as computers rapidly became faster and smaller, significant progress was made in picture projection and mechanical engineering related to VR. Ever-improving applications thus started emerging for use in primarily flight simulators and in the game and entertainment industry, with added components like more compact VR goggles, haptic feedback gloves, and real-time computer-generated graphics. By the end of 2020, several million VR sets with much-increased capabilities had been sold, primarily to video gamers (Fig. 1).

Motivation

The advancement of VR technology, such as continual miniaturization, led to improved resolution, more reasonable price-tags, ease of use, etc., and was thus introduced to a considerably broader extent in a variety of fields, including education. The COVID-19 pandemic that seriously began affecting the world in 2020, and paralyzed much of it for about two years, brought to forefront the need for alternative methods of carrying on everyday tasks, with a major impact on not least education at all levels.

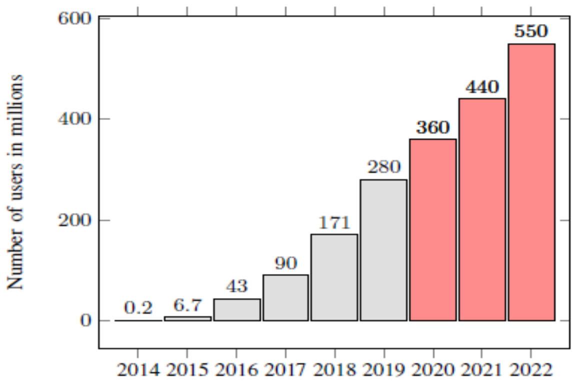

Figure 1. The number of actual and projected VR users in millions 2014-2022 (Kenwright, 2020).

Objective

The purpose of this study is to examine how virtual reality tools can better be used to assist and augment student learning, by way of an in-depth survey, data processing, statistical analysis, and fact-based conclusions. The main objective is to conduct a thorough statistical analysis using data collected from a diverse and fairly represented body of students, and identify any statistically significant conclusions differentiated by various independent variables, such as gender, ethical background, age, area of study, grades, seniority, etc. These findings, distilled from the survey's multiple-choice and free-form answers, form a basis from which to develop pilot studies that examine effective use of VR in general education. The principal research questions (RQ) addressed are as follows:

RQ1. What do students in general education feel the main barriers and worries for VR adaptation are in terms of improving learning effectiveness?

RQ2. What realistic suggestions do they have to improve on that?

RQ3. Would students be open to commit to some radical changes in educational methodology, and provide regular feedback to aid improvements?

RQ4. Does experience with VR in gaming environments influence perceptions about the use of VR in educational settings?

This study focuses on college students, and how they can be assisted by VR in learning their curriculum more effectively, especially in times when many schools are partially open and subject to virtual learning from home.

Methodology

The multiple-choice portion of the survey was evaluated using Pearson's qualitative χ^2 test that calls for a statistical analysis of ordinal data. This method is used to determine whether there is a statistically significant difference between the expected frequencies and the observed frequencies in one or more categories of a contingency table. This makes it amenable to study the influence of discriminators like gender, race, age, etc., to an arbitrary degree of confidence. The null hypothesis H_0

is always worded in a way that states that there is no statistically significant difference between groups subdivided by, say, gender. By comparing the calculated χ^2 statistic with the critical χ^2 value (from a table that states that value based on the degrees of freedom and the desired accuracy), one can thus either accept H_0 and conclude that, in this example, gender does not significantly affect the outcome, or fail to reject H_0 and thereby accept H_1, the alternative hypothesis, which concludes that gender does indeed make a difference as to the students' cumulative answers, to a statistically significant degree. We adopt a standard scientific accuracy of p=0.05 as the cut-off, but also report in each case the p-value so that the reader can distill more information out of the results (e.g., a calculated p=0.06 means that H_1 is appropriate to adopt, albeit at a slightly more relaxed confidence interval than p=0.05).

Results

The survey was distributed to 154 college students, 52% males and 48% females, 6 distinct race / ethnicities, predominantly Asian, White, and Hispanic/Latino (79%), and the remainder of the respondents identifying as Black/African-American, Pacific Islanders, or mixed race. About 2/3 of all students had GPAs >3.2, and the average student age was 19-20 years old. Sophomores made up about 1/3 of all students, whereas freshmen, juniors, and seniors each accounted for about 1/5 of the student pool. The response rate was quite high, >90%, at a 96% response rate for multiple-choice questions and an 81% response rate for free form questions.

This study was reviewed and approved by the Pacific University Institutional Review Board. The participation was voluntary, with anonymity guaranteed. Each individual was provided a brief explanation about the purpose of the study, how individual data will be used statistically only, fully anonymously, and all personal data privacy laws, abiding by all federal, state, and University Governing Board rules. All data is stored in encrypted files, and any paper versions are locked up in a secure storage facility.

For the χ^2 analysis to be meaningful and reliable, no single subgroup was allowed to contain less than 5 students. This forced a lot of combining smaller groups together to be able to carry out the analyses, more so for looking at race/ethnicity as a potential discriminator than gender, simply because there were six subgroups of race/ethnicity and only two for gender. In addition, the more extreme answers (e.g., "very much agree", "do not agree at all") tended to be sparsely populated so the grouping had to occur on several levels, see Tables 1 and 2 for a specific research question example (Lal, 2022).

Table 1. Race/ethnicity distribution for a specific research question.

	Very experienced	Experienced	Somewhat experienced	Very limited experience	No experience	No answer	Total
Total	**6**	**20**	**39**	**47**	**36**	**6**	**154**
Asian	3	5	12	16	12		
Hispanic/Latin	0	2	7	12	9		
White	3	9	9	12	10		
Black / African American	0	2	0	1	1		
Pacific Islander	0	0	2	1	0		
Mixed	0	1	8	3	2		
Unclear	0	1	1	2	2		
Sum check	6	20	39	47	36	6	**154**

Table 2. Consolidated race/ethnicity distribution for a specific research question.

	Very experienced	Experienced	Somewhat experienced	Very limited experience	No experience	No answer	Total
Total	6	20	39	47	36	6	154
Asian	3	5	12	16	12		
Hispanic/Latin	0	2	7	12	9		
White	3	9	9	12	10		
Black / African American	0	2	0	1	1		
Pacific Islander	0	0	2	1	0		
Mixed	0	1	8	3	2		
Unclear	0	1	1	2	2		
Sum check	6	20	39	47	36	6	154

In this specific example, the "experienced" and the "very experienced" groups were combined. In addition, Hispanic/Latin, Black / African American, and Mixed race/ethnicities were combined into one named "other" to ensure we could proceed with. In other cases, we got away with less course graining, and in yet others we had to eliminate certain rows/columns.

The survey questions address the four research questions, as illustrated in Tables 3-4. The first six questions relate to the demographics of the participants, and two specific ones were used as differentiators in the statistical analyses:

D1. "How old are you?"
D2. "What is your current enrollment status?"
D3. "What is your current major?
D4. "Which gender do you most identify with?"
D5. "What is your race/ethnicity?
D6. "What is your current GPA?s

The next 12 questions were of the multiple-choice kind, as follows:

MC1. "Do you engage in gaming that uses VR?"
MC2. "How aware are you of current use of VR in any applications?"
MC3. "Do you feel that VR is used effectively in today's education?"
MC4. "How experienced are you with any kind of VR in games, learning, etc.?"
MC5. "Would you be interested in further or extended use of VR to help with your learning?"
MC6. "Do you feel that your education center has sufficient resources/capacity to assist with VR learning?"
MC7. "Has the Covid-19 pandemic changed the amount of VR technology you use?"
MC8. "Has the Covid-19 pandemic influenced your views about whether VR should be implemented more aggressively?"
MC9. "How worried are you about VR having a negative impact on your learning and/or grades?"
MC10. "Do you feel that VR should be applied in all areas of teaching?"
MC11. "How willing would you be to commit to radical changes in educational methodology (e.g., the use of VR)?"
MC12. "I would be willing to provide regular feedback in order to improve the implementation of VR in the curriculum."

Table 3. Research questions addressed by multiple-choice survey questions.

	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9	MC10	MC11	MC12
RQ1						■			■	■		
RQ2												
RQ3			■		■						■	■
RQ4		■	■	■						■		

Table 4. Research questions addressed by free-form questions.

	OE1	OE2	OE3	OE4	OE5
RQ1		■	■	■	
RQ2		■			■
RQ3					
RQ4	■				

The five free-form questions are:
OE1. “What are your current thoughts about the use of VR in education?”
OE2. “What are your primary concerns about expanding the use of VR in education? What do you perceive to be the main barriers to implementation?”
OE3. “What do you feel would be the greatest benefits of increasing the use of VR in education?”
OE4. “Do you have any other concerns or thoughts about this topic?”
OE5. “What recommendations would you give teachers and others responsible for your schooling when it comes to VR?”

Using the answers, we thus performed a χ^2 (chi-square) analysis to determine any statistically significant differences at the p=0.05 level based on the differentiators addressed by the six demographics questions (see above). For most of the multiple-choice questions, we find no statistically relevant difference between the differentiators. The first minor tendency we note, at the p=0.14 level, is that males exude more opinions than females regarding the effective use of VR in education (MC3). We do find a statistically relevant difference (p=0.048) based on gender in terms of prior experience with the use of VR: *males are on average more experienced with using VR than females*. We also found a statistically significant gender-based difference with regard to question MC5, which asks the subjects whether they are interested in extended use of VR to help with learning: *males are overall more interested in further use of VR in learning environments.* The next statistically significant finding concerns the willingness to commit radical changes in educational methodology (e.g., VR), see MC11. Here, at the p=0.053 level, we find that *males are overall more open to radical changes in educational methodology, including VR.* The first statistically significant finding based on ethnicity/race came from the answers to MC12 (p=0.056): *Hispanics/Latinos, Pacific Islanders, Black / African Americans, and those of mixed race/ethnicity are overall more inclined to provide ongoing feedback regarding the implementation of VR in the curriculum*. The results are summarized in Table 5 (Lal, 2022).
A considerably more detailed description of the study, with further illustrations garnered from the answers to both multiple-choice and free-form questions can be found in the dissertation thesis by Lal, A. (2022).

Discussion

The principal purpose of this study is to examine student perceptions on how VR tools can be used effectively to augment and assist student learning. Another goal is to gauge general attitudes, worries, perceived barriers, levels of enthusiasm, commitment to implementation, and willingness to provide ongoing feedback to improve the process upon roll-out. A third goal was to determine whether there are any statistically significant differences ($p<0.05$) between genders and race/ethnicities, and potentially other discriminators in regard to the findings. In the following, we address key findings with regard to the four RQs we set out to answer.

Table 5. Key χ^2 statistics for establishing potential gender and race/ethnicity discriminators in multiple-choice questions (p=calc. value; p_0=default cut-off).
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		MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9	MC10	MC11	MC12
Gender	χ^2 (df)	1.650	1.128	4.034	7.886	9.215	5.271	0.623	4.353	7.436	1.637	5.889	3.785
	χ_c^2(df)	3.841	9.488	5.991	7.815	7.815	9.488	5.991	7.815	9.488	7.815	5.991	7.815
	p	0.199	0.890	0.133	0.048	0.027	0.261	0.732	0.226	0.114	0.651	0.053	0.286
Race/Ethnicity	χ^2 (df)	1.688	N/A	3.188	6.117	3.492	3.400	1.217	2.302	1.854	5.004	5.279	9.198
	χ_c^2(df)	7.815	N/A	9.488	12.59	12.59	9.488	5.991	12.59	9.488	9.488	9.488	9.488
	p	0.640	N/A	0.527	0.410	0.745	0.493	0.544	0.890	0.763	0.287	0.260	0.056
	P_0	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

In terms of RQ1, we note that about 2/5 of the respondents consider their schools to have excellent VR resources, about 1/4 that they have limited resources, and the remainder feel that there are not sufficient resources or have no opinion. Delving into the free-form answers for further insight, almost a third of the students quote cost as a very large barrier for use of VR in learning environments, and quite a few also worry about health issues that increased use of VR may cause: health issues such as nausea, dizziness, headaches, situational awareness, and/or feelings of disassociation. Other worries include a taxing learning curve, for teachers and students alike, and potential distraction from more conventional learning. More than half of the students did not worry about the impact on grades that use of VR might entail.

With regard to the second RQ, the main takeaway from the students' free-form answers is their concern about the availability of sufficient funding to expand the use of VR in classroom settings. They again reiterate their health concerns (see above), and a number of them also worry about good teachers losing their jobs because they cannot cope with VR technology. The health concerns are nothing new or surprising; see, e.g., Winn & Jackson, 1999, but need to be taken seriously.

Looking at RQ3, students' perception of effective VR use and openness to radical changes in educational methodology, almost half of the study participants felt that VR is being effectively used in school settings, and equally many felt interested or very interested in further expanding the use of VR for these purposes. Moreover, the χ^2 analysis reveals that males rather than females are the driving force for further use of VR in schools ($p=0.027$), and that out of the ~80% of students supporting such development, again, males are committed to radical changes ($p=0.053$). Moreover, it is predominantly Hispanic/Latinos, Black / African Americans, Pacific Islanders, and those of mixed race that seem

more inclined to provide ongoing feedback of VR use in the curriculum than either Asians or non-Hispanic Whites (p=0.057).
In response to RQ4, whether experience with VR gaming influences perceptions about using the technology in educational settings, over 4/5 of the respondents state that they are aware or somewhat aware of VR applications, mainly because of some prior experience observing or partaking in VR activities in school settings. In addition, about 3/5 feel that VR should be applied in all areas of teaching. Overall, these responses are in line with previous studies, where 89% of the respondents (100 participants) stated that they strongly agreed or agreed that VR was an innovative application that has pedagogical benefits, which is on the same order of as this study finds in a similar question (82% of students in this study are interested to some degree in further/extended use of VR for general education purposes). The study by Baxter & Hainey (2019) also found the same significant gender difference as was found in this study – males are considerably more interested in the future and expansion of VR than females.

Conclusions

In conclusion, we have developed and carried out a plan to learn more about students' past, present, and future views toward the use of VR in learning settings. Analyzing a sizeable database with statistical tools, ensuring compliance with all applicable privacy laws, we reveal some interesting trends that can be used to streamline future research and to develop pilot studies in a controlled manner to gain further insight into how VR complements standard learning methods. The main obstacles to introducing VR as a mainstay technology in classrooms appears to be the associated cost of equipment and software required for that purpose, the training of both teachers and students in how to use VR effectively, and a necessity for good planning and oversight to ensure minimal misuse or negative consequences from too much VR exposure

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