

INVESTIGATING THE EFFECT OF 3D IMMERSIVE VIRTUAL REALITY TECHNOLOGY ON STUDENT INTEREST, MOTIVATION AND PERFORMANCE IN UNDERGRADUATE CHEMISTRY

Donna Hitlal - Department of Chemistry, Faculty of Science and Technology, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago. Tel: 868 684 3622 and Email: donna.hitlal@my.uwi.edu

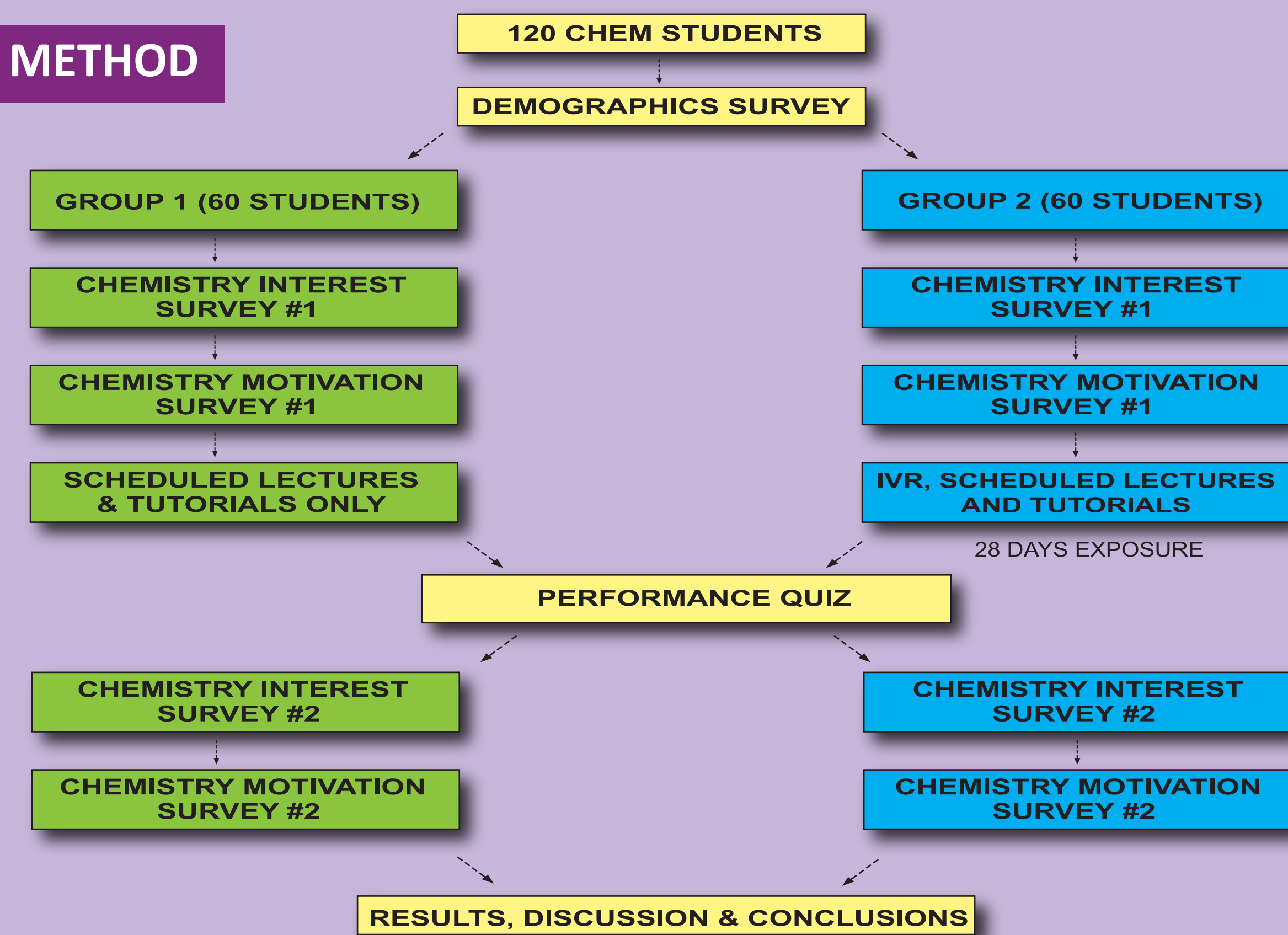


ABSTRACT

Advancements in virtual reality technology combined with increasing demands to take chemistry out of the traditional lecture hall and laboratory have paved the way for chemical education researchers to investigate the possible benefits of new technology for teaching and learning chemistry. The present study investigated the use of 3D Immersive Virtual Reality (3D IVR) with Head Mounted Displays (HMDs) for teaching chemistry at the introductory undergraduate level. More specifically, the research looked into the effect of 3D IVR HMDs on student interest, motivation and performance in chemistry. The participants were first-year chemistry undergraduate students at The University of the West Indies, St. Augustine Campus (The UWI, STA) who volunteered to be a part of the research study (n=120). Study participants were divided equally into two groups (n=60) which were a control group and a test group. The Chemistry Student Interest Questionnaire (C-SIQ), the Chemistry Motivation Questionnaire (CMQ-II), a demographics survey and a post-trial quiz were used. The data collected was analyzed with the use of SPSS. Results showed that there was an overall increase in interest, motivation and performance for the students exposed to the 3D IVR content with the HMDs compared to students exposed to traditional lectures and tutorials only.

Keywords: Virtual Reality (VR); Head Mounted Displays (HMDs); Chemistry - Study Interest Questionnaire (C-SIQ), the Chemistry Motivation Questionnaire (CMQ-II), Chemistry and 3D Animation; Chemistry and Technology; Introductory Chemistry; Hands-on Learning

METHOD

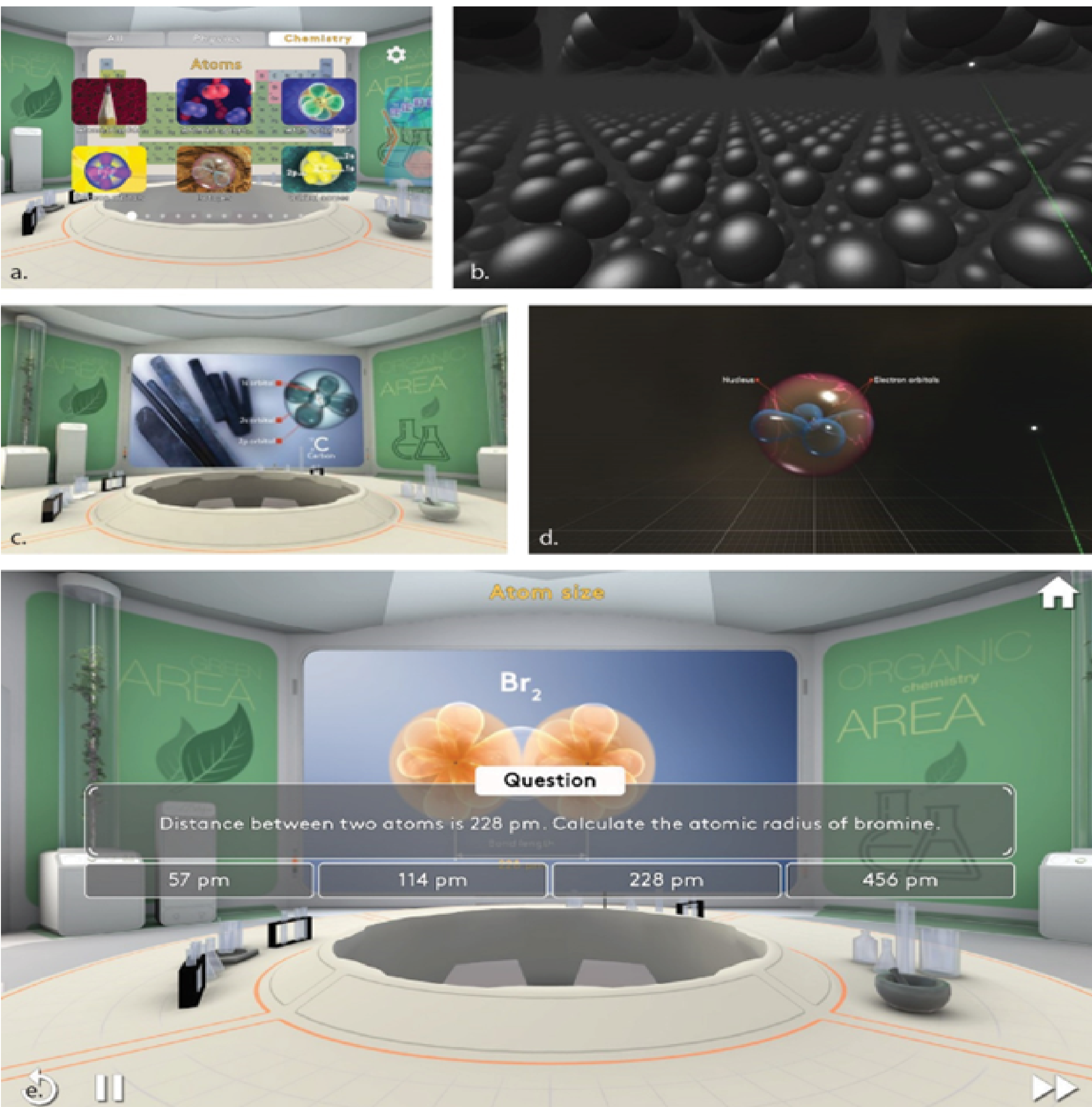


HARDWARE USED IN THIS PROJECT



Images from: <https://www.amazon.com/Headset-Compatible-Smartphones-Controller>

SOFTWARE USED IN THIS PROJECT



A sample of screenshots of the student's view inside the MEL VR.
a. Choosing the chemistry lesson,
b. students can zoom in a billion times to see a carbon atom,
c. a view inside of the carbon atom,
d. a view of the orbitals of the carbon atom,
e. an example of the questions after each VR lesson

RESULTS

$H_0: I_{Grp1reading\ 1} = I_{Grp1reading\ 2} (H_01)$
 $H_0: I_{Grp2reading\ 1} = I_{Grp2reading\ 2} (H_02)$ where I=Chemistry Interest

A One-Way ANOVA was performed on both groups to determine if the null hypotheses were to be rejected in each case.

Anova: Single Factor Group 1 (Control Group)						
Groups	Count	Sum	Average	Variance		
Group 1 Reading 1	60	176.5556	2.942593	0.112154		
Group 1 Reading 2	60	176.6111	2.943519	0.109489		
ANOVA						
Source of Variation	SS	df	MS	F	P-val	F crit
Between Groups	2.57E-05	1	2.57E-05	0.000232	0.987871	3.921478
Within Groups	13.0769	118	0.110821			
Total	13.07693	119				
Critical Value, $\alpha = 0.05$						
For Group 1, the P-value = 0.987871, so we fail to reject the null hypothesis:						
$H_0: I_{Grp1reading\ 1} = I_{Grp1reading\ 2} (H_01)$ where I=Chemistry Interest						

Anova: Single Factor Group 2 (IVR Exposed Group)						
Groups	Count	Sum	Average	Variance		
Group 2 Reading 1	60	169.8333	2.830556			
Group 2 Reading 2	60	142.0556	2.367593			
ANOVA						
Source of Variation	SS	df	MS	F		
Between Groups	6.430041	1	6.430041	21.33408	9.91E-06	
Within Groups	35.56492	118	0.301398			
Total	41.99496	119				
Critical Value, $\alpha = 0.05$						
For Group 2, the P-value = 9.91E-06, so we reject the null hypothesis:						
$H_0: I_{Grp2reading\ 1} = I_{Grp2reading\ 2} (H_02)$ where I=Chemistry Interest						

$H_0: M_{Grp1reading\ 1} = M_{Grp1reading\ 2} (H_03)$
 $H_0: M_{Grp2reading\ 1} = M_{Grp2reading\ 2} (H_04)$ where M=Chemistry Motivation

Anova: Single Factor for Groups 1 and 2						
Groups	Count	Sum	Average	Variance		
Group 1 Reading 1	60	164.19	2.7365	0.307918		
Group 1 Reading 2	60	163.88	2.731333	0.208113		
Group 2 Reading 1	60	173.4	2.89	0.337553		
Group 2 Reading 2	60	181.04	3.017333	0.132305		
ANOVA						
Source of Variation	SS	df	MS	F	P-val	F crit
Between Groups	3.384618	3	1.128206	4.577417	0.003891	2.642851
Within Groups	58.16743	236	0.246472			
Total	61.55205	239				
Critical Value, $\alpha = 0.05$						
For Group 2, the P-value = 0.003891, so we reject the null hypothesis:						
$H_0: M_{Grp2reading\ 1} = M_{Grp2reading\ 2} (H_04)$ where M=Chemistry Motivation						

One-Way ANOVA for Group 1 and 2 for Intrinsic Motivation						
Groups	Count	Sum	Average	Variance		
Int Mot. G1 R1	60	161.15	2.685833	0.378652		
Int Mot. G1 R2	60	166	2.766667	0.279548		
Int Mot. G2 R1	60	171.2	2.853333	0.412023		
Int Mot. G2 R2	60	173	2.883333	0.220056		
ANOVA						
Source of Variation	SS	df	MS	F	P-val	F crit
Between Groups	1.434281	3	0.478094	1.482141	0.220058	2.642851
Within Groups	76.12646	236	0.32257			
Total	77.56074	239				

One-Way ANOVA for group 1 and 2 for Grade Motivation						
Groups	Count	Sum	Average	Variance		
Gra. Mot. G1 R1	60	174.4	2.906667	0.449531		
Gra. Mot. G1 R2	60	173.2	2.886667	0.404565		
Gra. Mot. G2 R1	60	184.3	3.073333	0.374192		
Gra. Mot. G2 R2	60	186.8	3.113333	0.41948		
ANOVA						
Source of Variation	SS	df	MS	F	P-val	F crit
Between Groups	2.380667	3	0.793556	1.926376	0.125972	2.642851
Within Groups	97.21833	236	0.411942			
Total	99.599	239				

One-Way ANOVA for Group 1 and 2 for Self-Determination						
Groups	Count	Sum	Average	Variance		
Self Det. G1 R1	60	154.8	2.58	0.409085		
Self Det. G1 R2	60	152.4	2.54	0.240407		
Self Det. G2 R1	60	160	2.67	0.461921		
Self Det. G2 R2	60	184.6	3.08	0.268599		
ANOVA						
Source of Variation	SS	df	MS	F	P-val	F crit
Between Groups	10.91917	3	3.639722	10.54983	1.55E-06	2.642851
Within Groups	81.42067	236	0.345003			
Total	92.33983	239				

Further analysis of the factors was carried out using the One-Way ANOVA to detect any significant differences for the factors of Self-Determination, Self-Efficacy, Intrinsic Motivation, Career Motivation and Grade Motivation in Group 1 and Group 2.

One-Way ANOVA for Group 1 and 2 for Self-Efficacy				
Groups	Count	Sum	Average	
Self Effic. G1 R1	60	167.2	2.786667	
Self Effic. G1 R2	60	165.8	2.763333	
Self Effic. G2 R1	60	177.8	2.963333	
Self Effic. G2 R2	60	199.2	3.32	
ANOVA				
Source of Variation	SS	df	MS	F
Between Groups	11.89933	3	3.966444	10.83377
Within Groups	86.404	236	0.366119	1.08E-06
Total	98.30333	239		

One-Way ANOVA for Group 1 and 2 for Career Motivation				
Groups	Count	Sum	Average	
Car. Mot. G1 R1	60	163.4	2.723333	
Car. Mot. G1 R2	60	162	2.7	
Car. Mot. G2 R1	60	173.6	2.893333	
Car. Mot. G2 R2	60	161.6	2.693333	
ANOVA				
Source of Variation	SS	df	MS	F
Between Groups	1.6165	3	0.538833	1.404793
Within Groups	90.522	236	0.383568	0.242066
Total	92.1385	239		

$H_0: P_{Grp1} = P_{Grp2} (H_05)$
where P=Chemistry Performance

The performance comparison between Group 1 and Group 2			
Groups	n	Average	SD
Group 1	60	174.4	0.100673
Group 2	60	173.2	0.136071
$p=0.000739$ at $\alpha < 0.05$			
We reject the null hypothesis $H_0: P_{Grp1} = P_{Grp2} (H_05)$			
where P=Chemistry Performance			

CER
Chemical
Education
Research

CONCLUSION

For the group that was exposed to the IVR, there was found to be a significant difference ($p=9.91 \times 10^{-6}$, $\alpha=0.05$) after exposure when compared to the unexposed (control) group. **The null hypothesis (H02) was rejected as the results indicated that the IVR exposure increased the students' chemistry interest.**

The results also showed that there was a significant difference between the control group and the IVR exposed group for Chemistry Motivation. **The null hypothesis (H04) that the motivation level before and after IVR exposure was equal was rejected.** Of the five motivation factors, there were increases in self determination ($p=1.55 \times 10^{-6}$, $\alpha=0.05$) and self-efficacy ($p=1.08 \times 10^{-6}$, $\alpha=0.05$). However, it was found that there was no significant difference in the students' intrinsic, career and grade motivation after IVR exposure.

The findings indicated that there was an improvement in chemistry performance after IVR exposure. **The null hypothesis (H05) was rejected as there was found to be a significant difference in the quiz scores between the control and IVR exposed groups ($p=7.39 \times 10^{-4}$, $\alpha=0.05$).**

REFERENCES

- Gabunilas, L.; M., Adlao, E.M.Y.; Burns, K.; Chiu, J. S.; Sanchez, S. S. Utilizing Portable Virtual Reality in Teaching Chemistry. University of Science and Technology of Southern Philippines, Cagayan de Oro City, Philippines. 2018.
- MEL Chemistry VR Lessons. <https://melscience.com/US-en/vr/> (Accessed 11/11/2022).
- Schiefele, U.; Krapp, A.; Wild, K.P.; Winteler, A. (). Der "Fragebogen zum Studieninteresse" (FSI). The Study Interest Questionnaire (SIQ). Diagnostica. 1993. 39, 335–351.
- Glynn, S. M.; Brickman, P.; Armstrong, N.; Taasoobshirazi, G. Science Motivation Questionnaire II: Validation With Science Majors And Nonscience Majors. Journal of Research in Science Teaching. 2011. 48 (10), 1159–1176.



Commonwealth
Chemistry
Federation of Chemical Sciences Societies