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Investigating the Impact of Interactive Immersive Virtual Reality Environments in Enhancing Task Performance in Online Engineering Design Activities

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Presentation Overview

- INTRODUCTION
- RESEARCH MOTIVATION
- LITERATURE
- RESEARCH OBJECTIVE
- METHODOLOGY
- CASE STUDY
- CONCLUSIONS
- FUTURE WORK

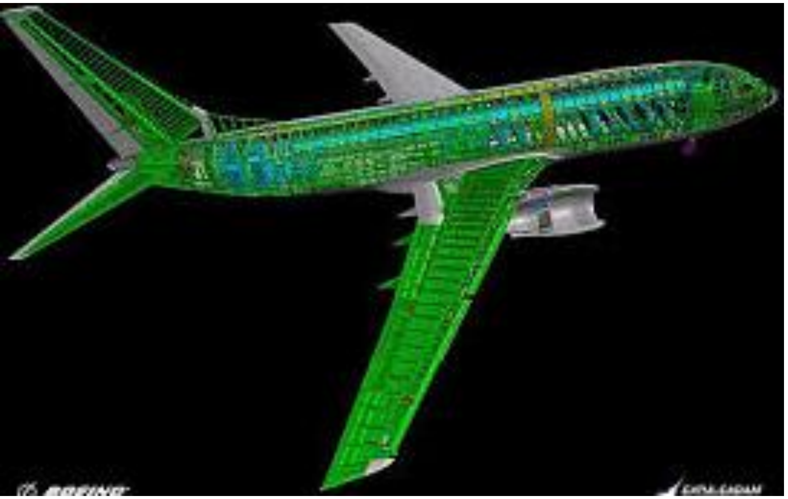
Engineers employ *virtual* and *tactile* approaches during learning activities

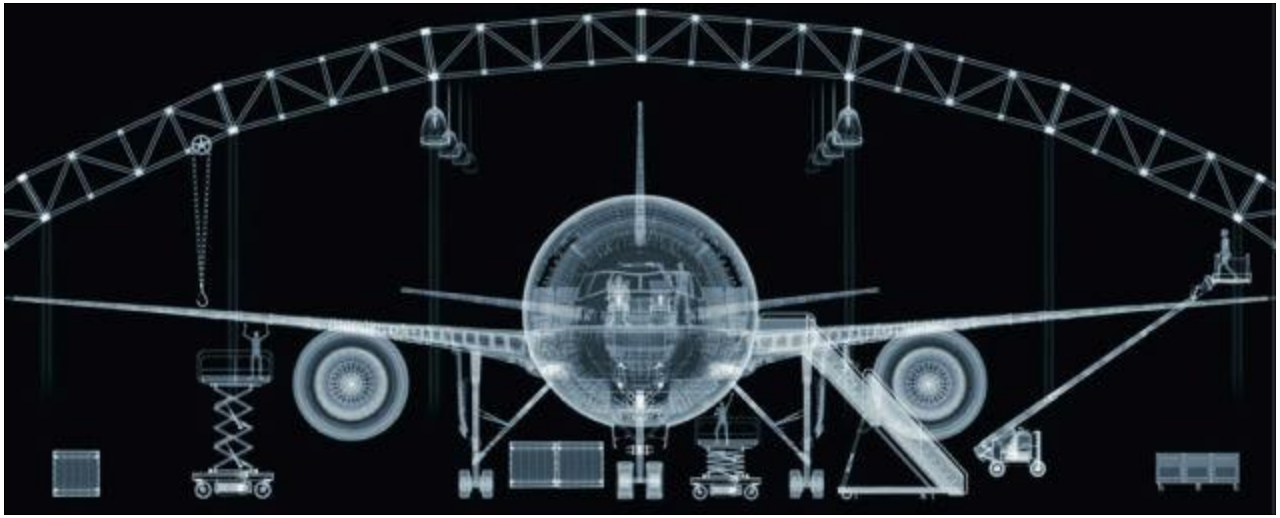
Virtual Learning (e.g., CAD)

Tactile Learning (e.g., Product Dissection)

McKenna et al, 2008; Lewis and Simpson (2009); Grantham et al. 2010; Moore-Russo et al (2010); Kremer et al., 2013; Tucker et al., 2014; Toh et al. (2014)

Virtual Design in Industry





What is Virtual Reality?

"Real-time graphical simulation with which the user interacts via some form of analog control, within a spatial frame of reference and with user control of the viewpoint's motion and view direction" *(Moshell and Hughes, 2002)*

Virtual Reality Literature

- 3D virtual worlds are more effective than text-based or 2D environments and can lead to better student engagement in learning activities *(Tashiro and Dunlap, 2007)*
- VR enables students to visit virtual environments and interact with objects and space in real time, which overcomes the traditional distance, time, or safety constraints *(Çaliskan, 2011; Ramasundaram et al., 2005)*

Types of Virtual Reality Paradigms

Two major types of Virtual Reality (VR) Paradigms

Immersive VR System

Non-immersive VR System

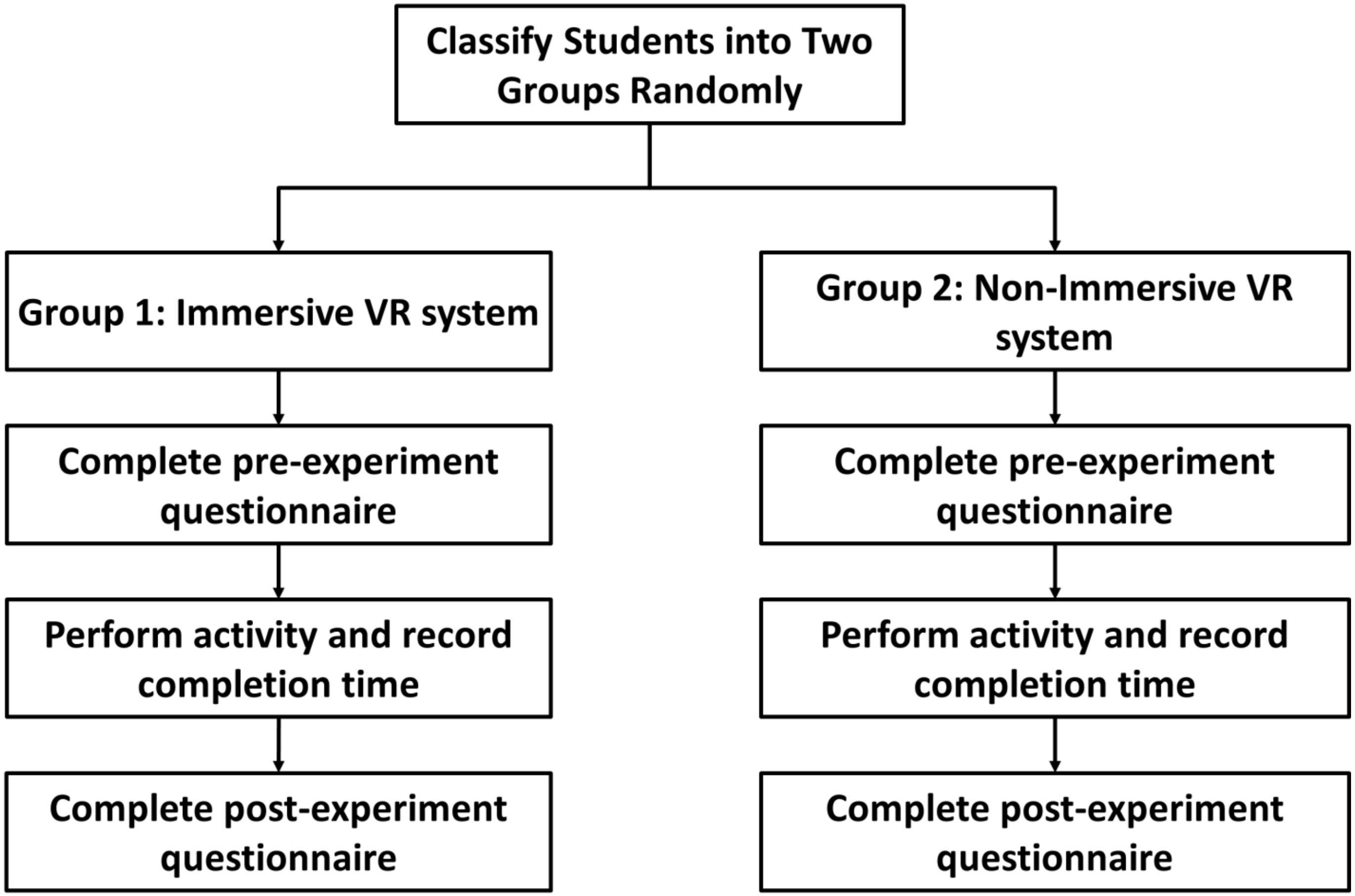
Research Objective

Hypothesis: There exists a statistically significant difference in task completion times between students using immersive VR and non-immersive VR system

Immersive VR System

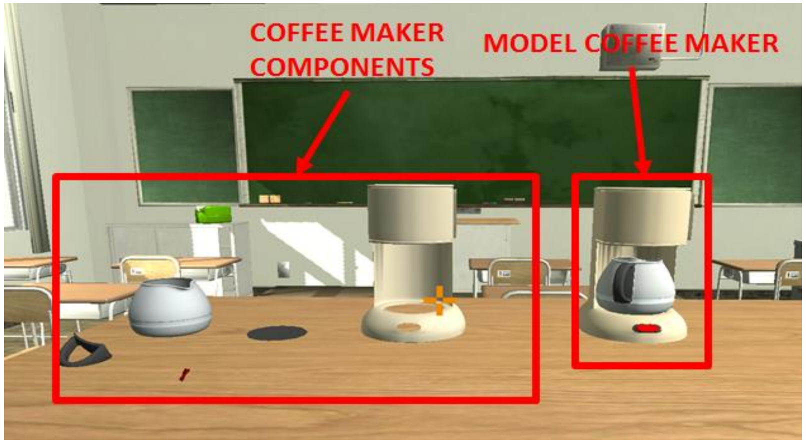
Non-immersive VR System

Methodology

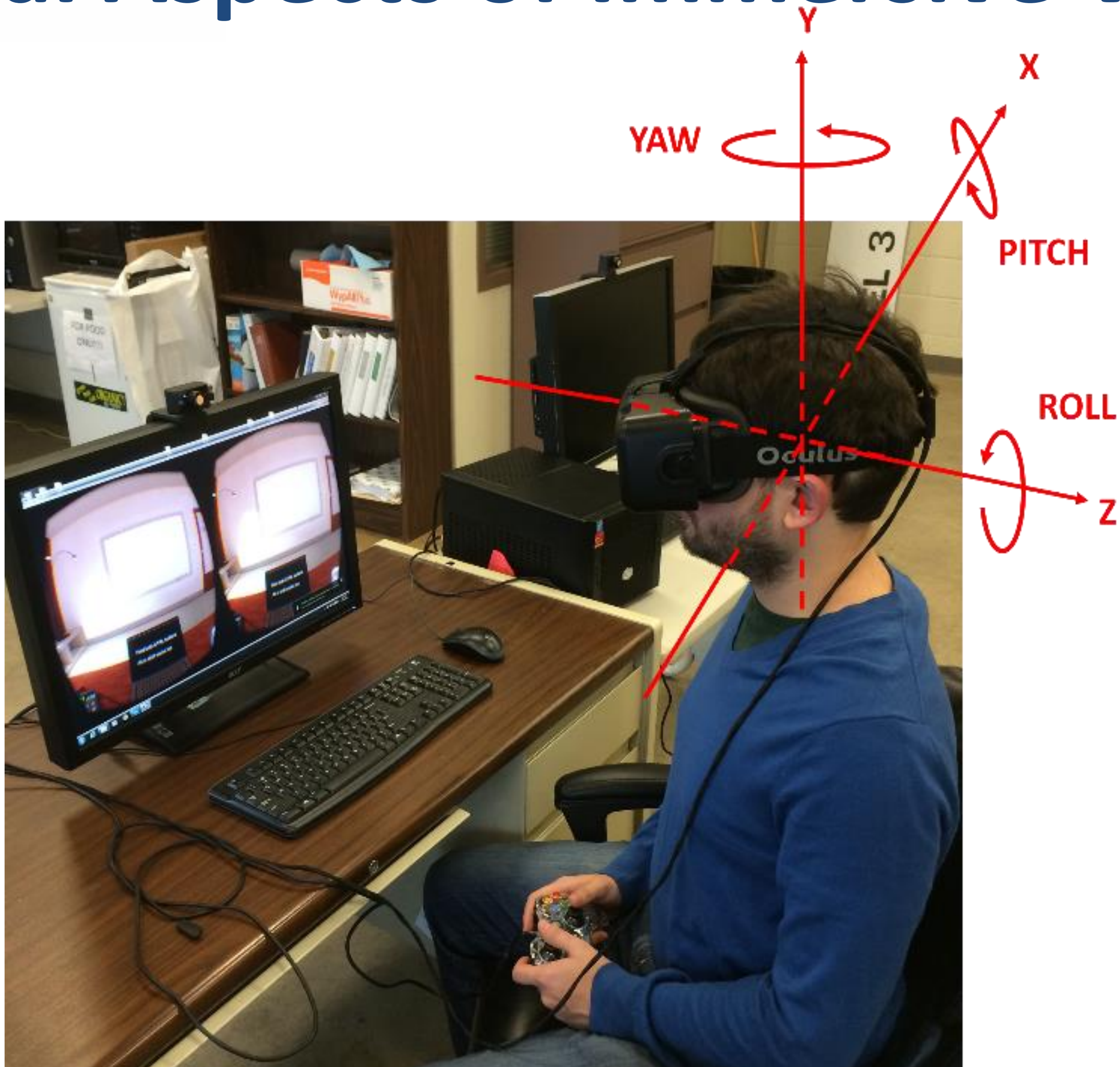


Study Sample

- 54 undergraduate students
- Immersive VR Group (29 students)
  - Head-mounted displays (Oculus Rift®) + game joystick
- Non-Immersive VR group (25 students)
  - Computer Screen + game joystick
- Activity Performed: Product Functional Assembly of Coffeemaker

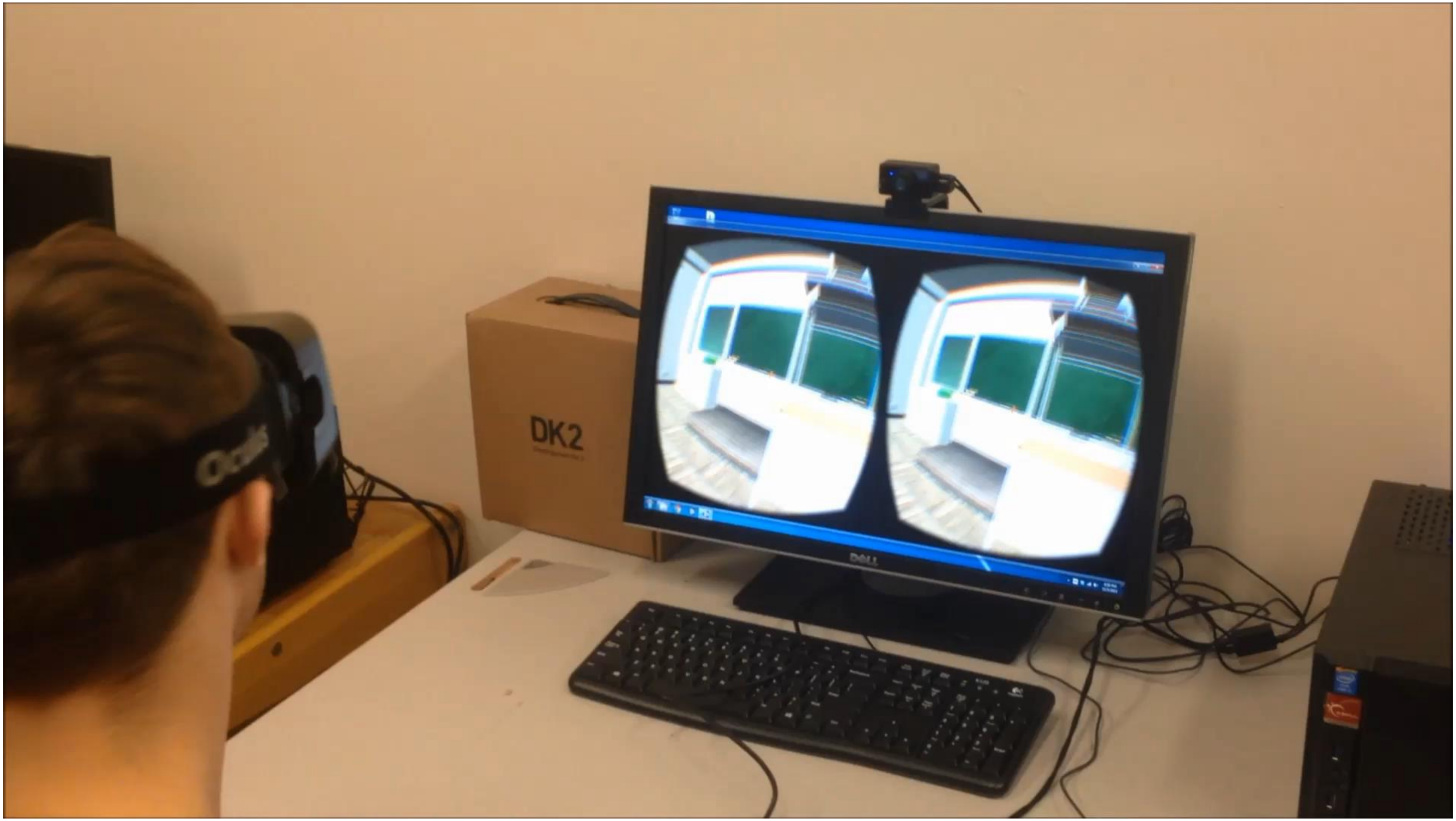


Spatial Aspects of Immersive VR



Immersive VR Demo

Click to Play



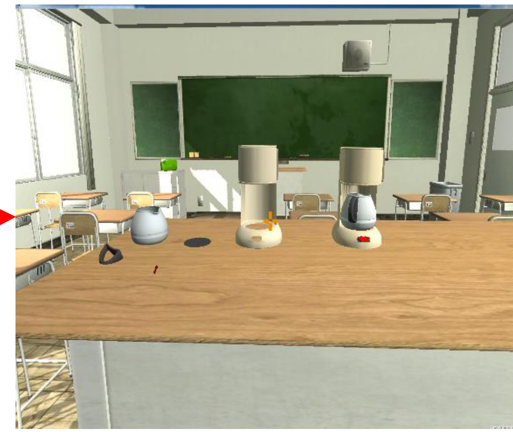
Experimental Setup

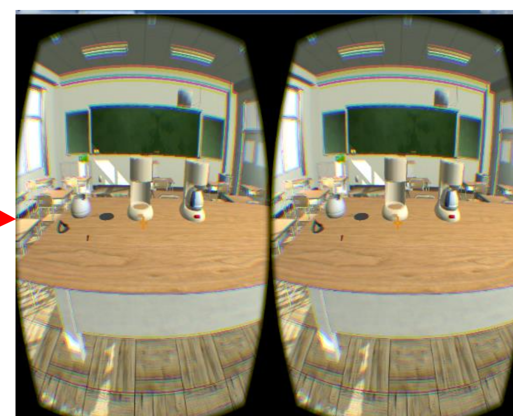
Random Classification of Students

Non-Immersive VR Group

Immersive VR Group

Product Functional Assembly in the Virtual Environment



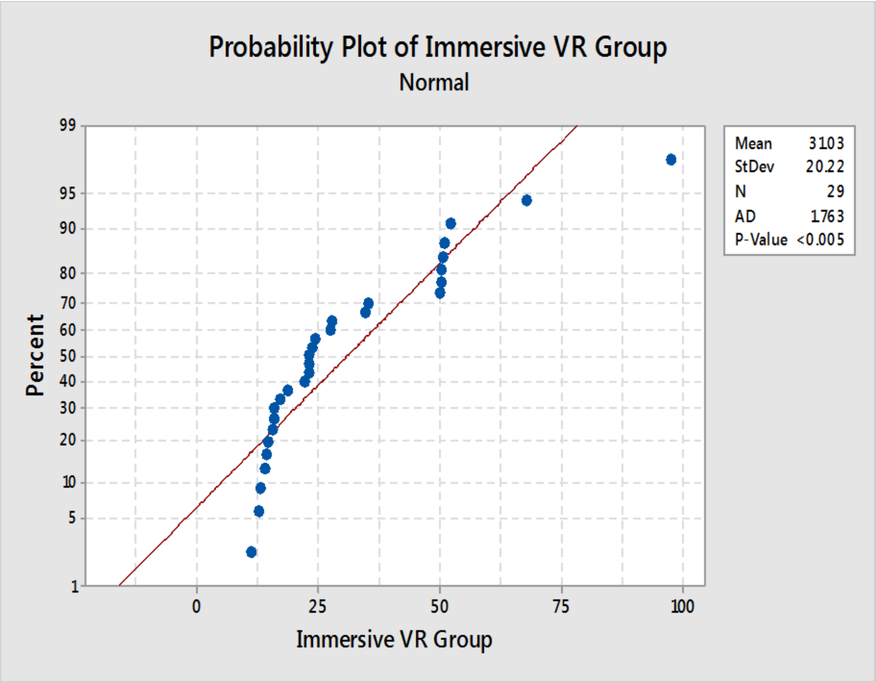


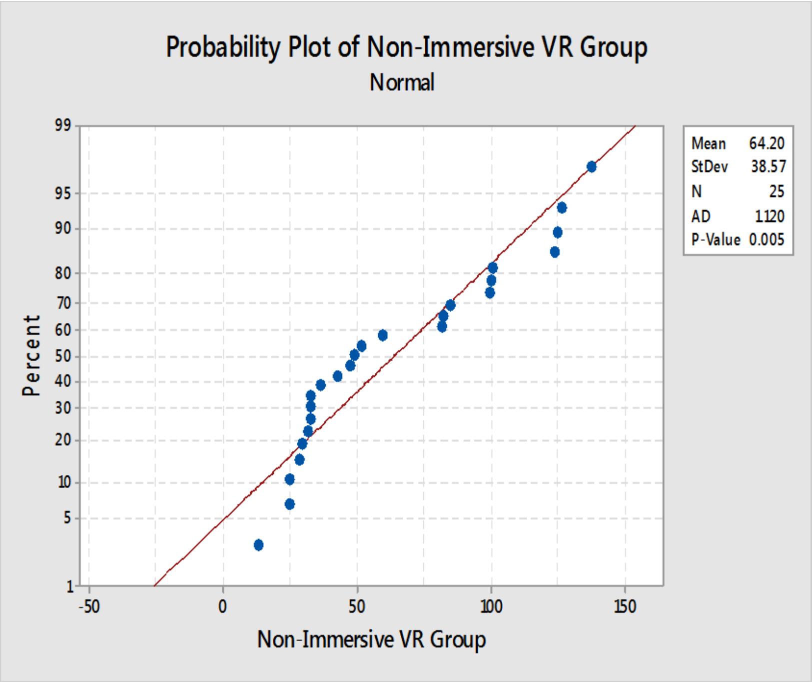
Record Task Completion Time and Perform Statistical Analysis

Measure Task Completion Time

- Task completion time has been used as a performance metric to evaluate the effectiveness of VR technology in research (Hwang et al., 2006) ; (Newmark et al., 2007) ; (Jennett et al., 2008); (Lendvay et al., 2013)

Test for Normality

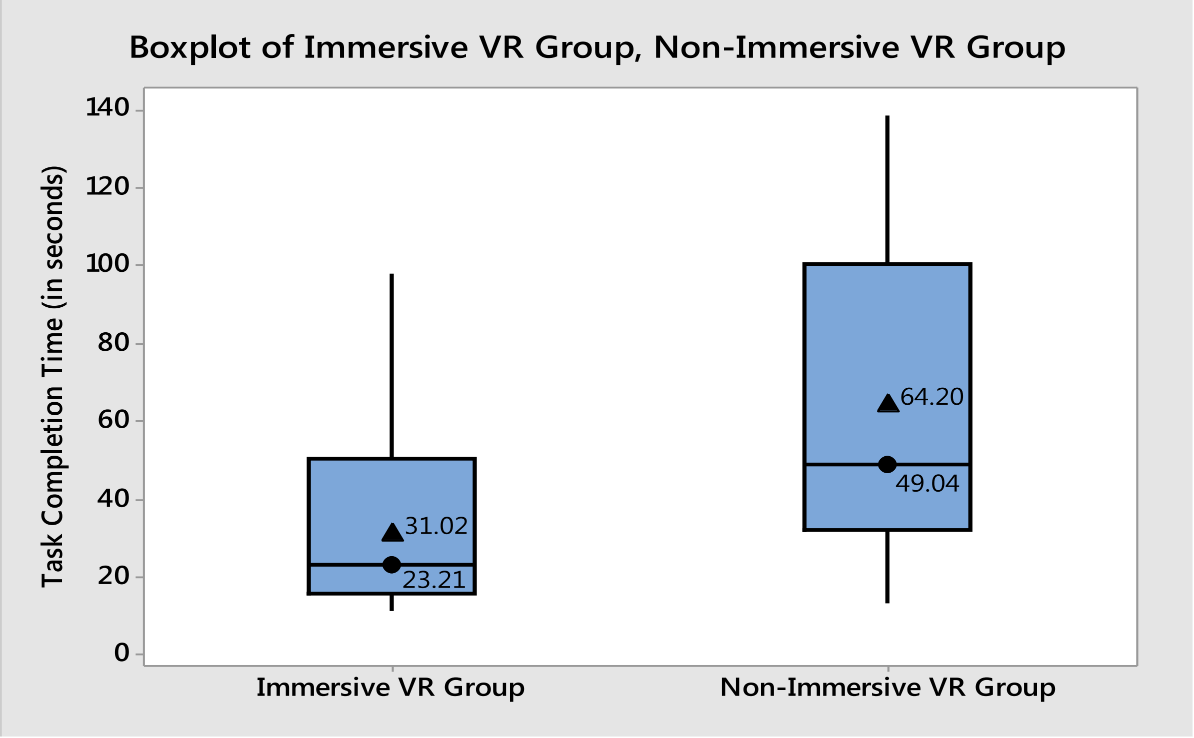




Samples do not follow normal distribution and sample sizes are not significantly large enough to assume normality – Select a Non-Parametric test (Mann-Whitney U Test)

Difference in Task Completion Times

Group	N (Sample Size)	Median Completion Time (in Seconds)
Group 1: Immersive VR	29	23.21
Group 2: Non-Immersive VR	25	49.04



Mann-Whitney U Test.
(p-value = 0.0001)

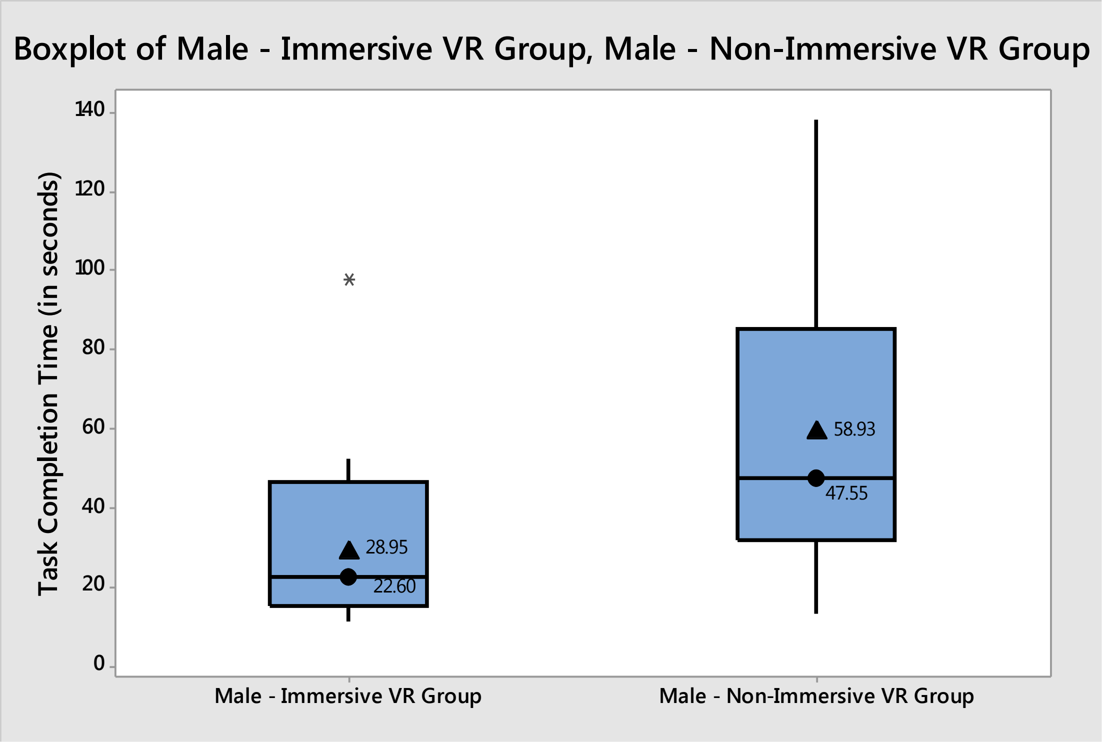
Immersive VR group students' task completion time significantly less than non-immersive VR group students

Investigate Why Differences Exist

- Three other hypotheses were tested to explore the reasons for the observed difference in performance outcomes between the two groups of students:
  - Gender
  - Prior level of joystick experience
  - Class Standing

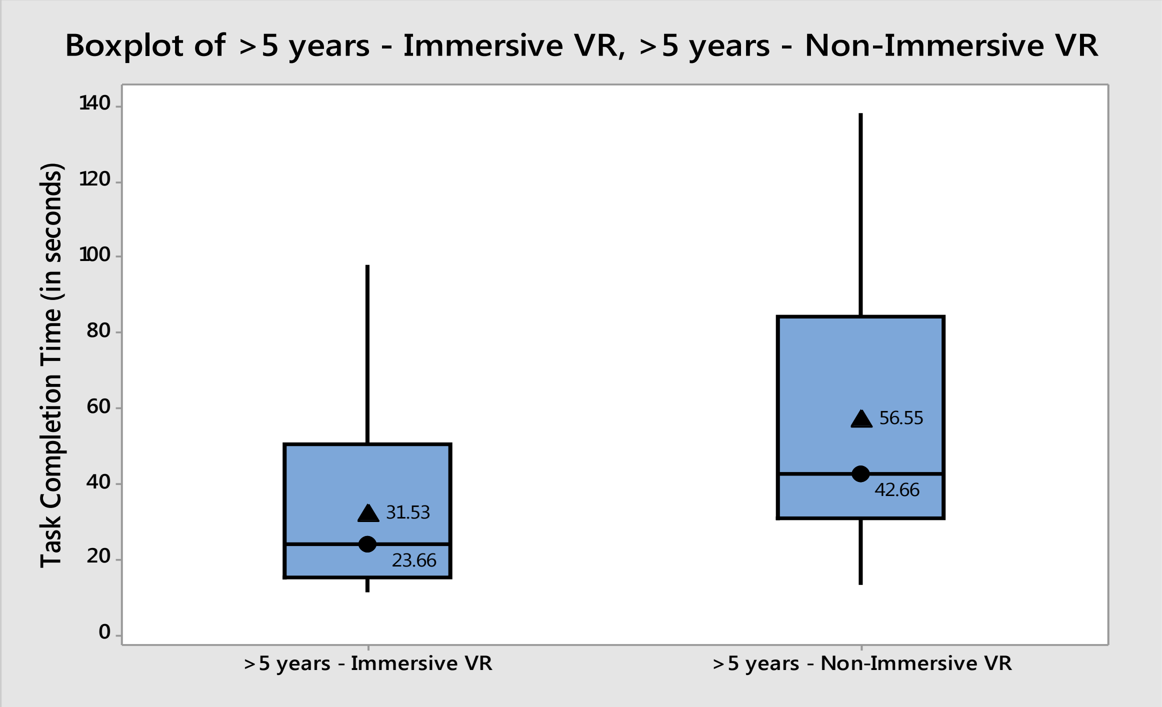
Hypothesis: Gender Differences

Hypothesis	Levels	Statistical Test	P value	Conclusion
Gender	Male	Mann-Whitney U Test	0.0002	Immersive VR students performed better than non-immersive VR students



Hypothesis: Joystick Experience Level

Hypothesis	Levels	Statistical Test	P value	Conclusion
Prior Level of Joystick Experience	>5 Years	Mann-Whitney U Test	0.0066	Immersive VR students performed better than non-immersive VR students

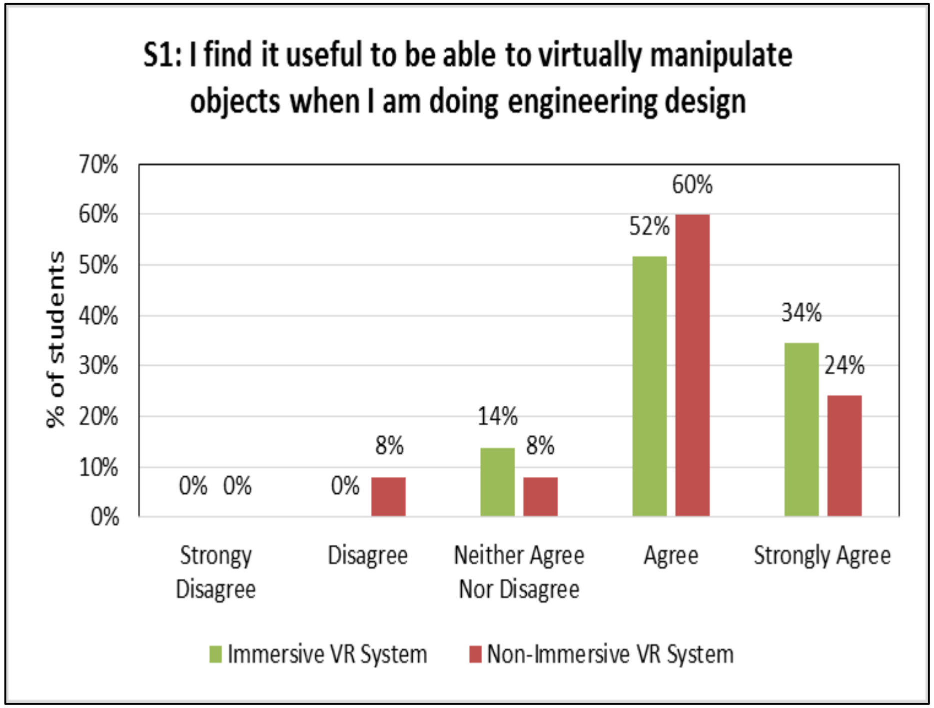


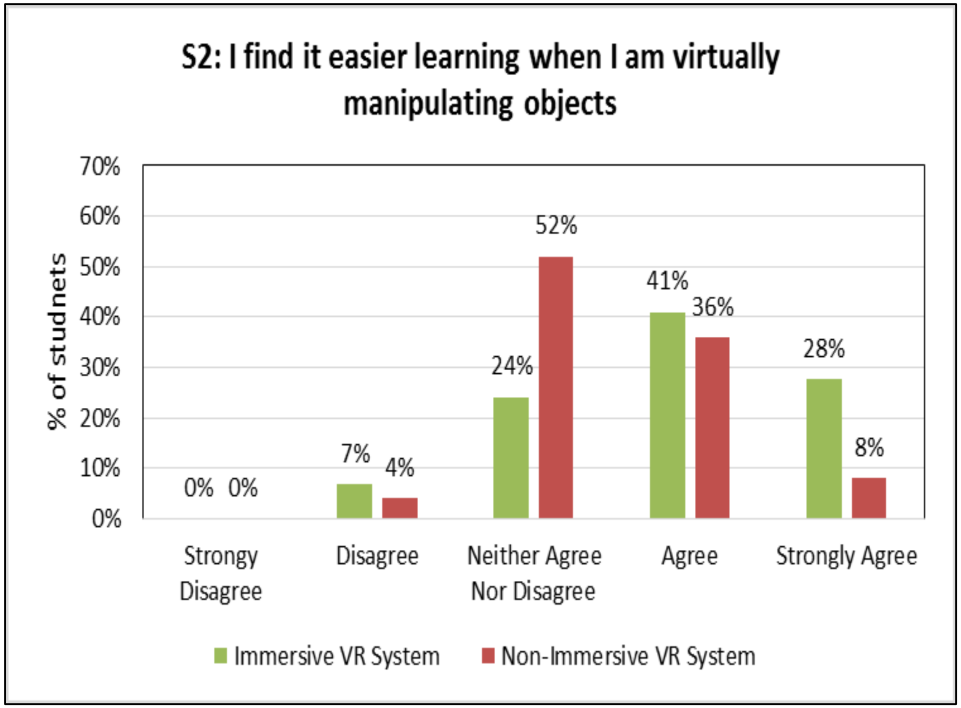
Hypothesis: Class Standing

Hypothesis	Levels	Statistical test	Conclusion
Class Standing	Freshman	Mann-Whitney U test	Immersive VR students performed better than non-immersive VR students*
	Sophomore	Mann-Whitney U test	Immersive VR students performed identical to non-immersive VR students*
	Junior	Mann-Whitney U test	Immersive VR students performed better than non-immersive VR students*
	Senior	Mann-Whitney U test	Immersive VR students performed identical to non-immersive VR students*

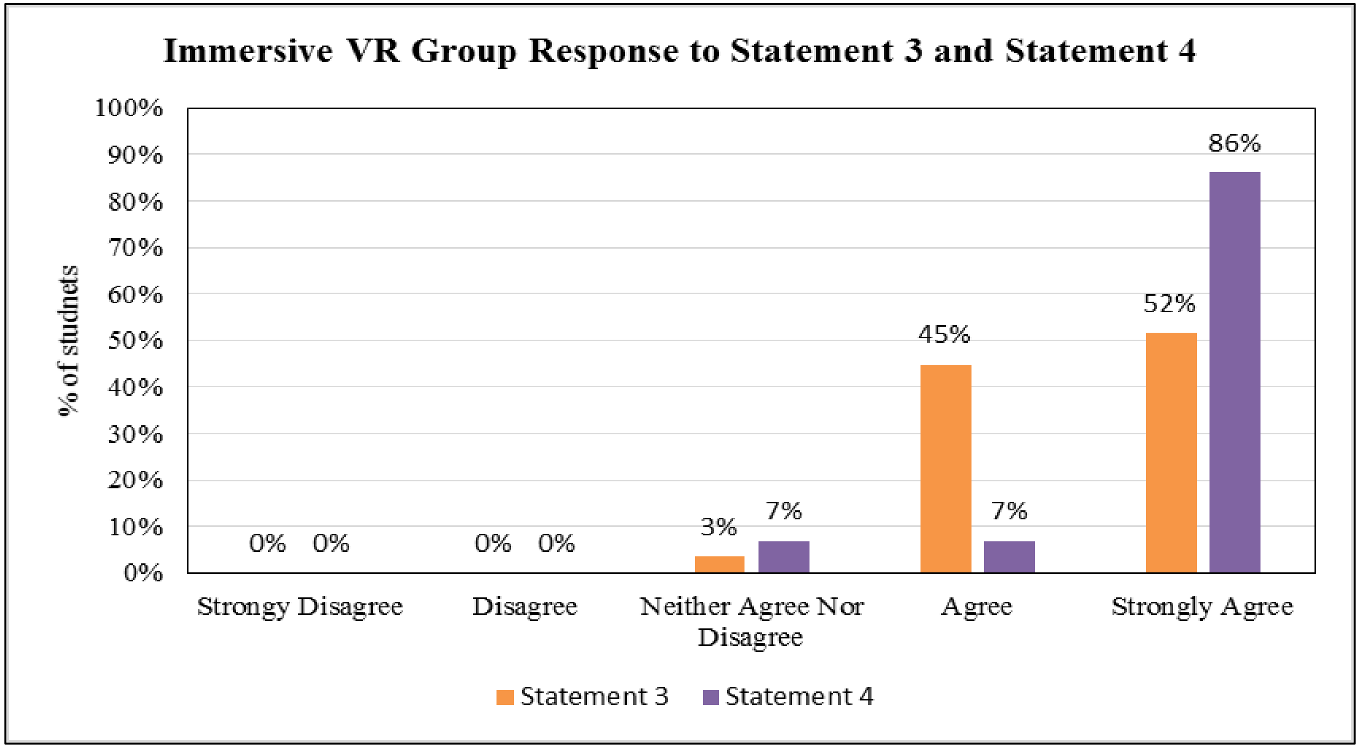
* - Tests performed using small sample sizes – results need further validation

Summary of Students' Feedback





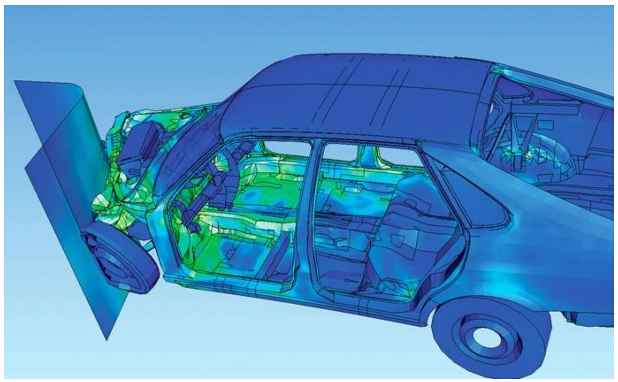
Summary of Students' Feedback



- **Statement 3:** *Virtual reality technology such as Oculus Rift® can be useful as a classroom tool*
- **Statement 4:** *I will be interested in enrolling in a class that uses virtual reality technology such as Oculus Rift®*

Virtual Reality in Education

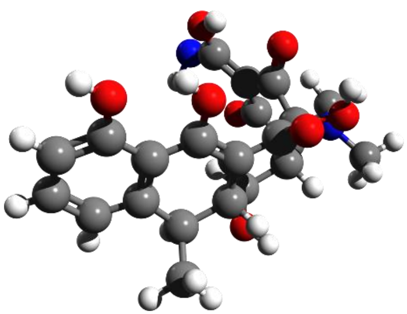
Product Design



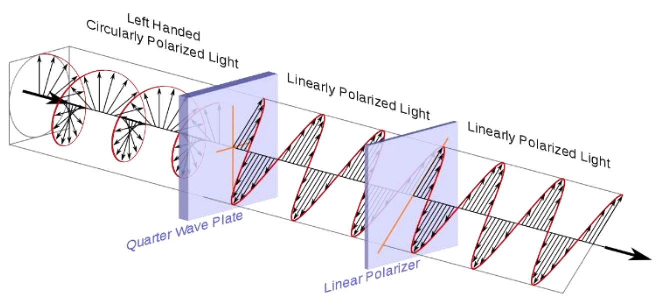
Medicine

Flight Training

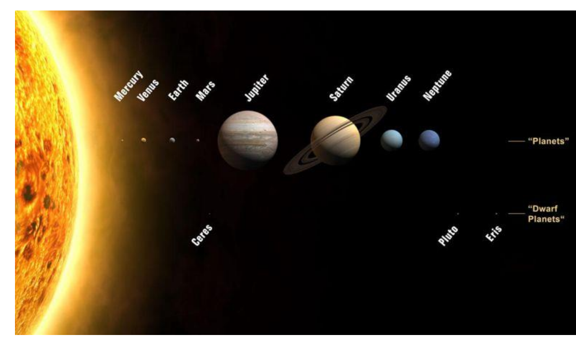
Chemistry



Physics

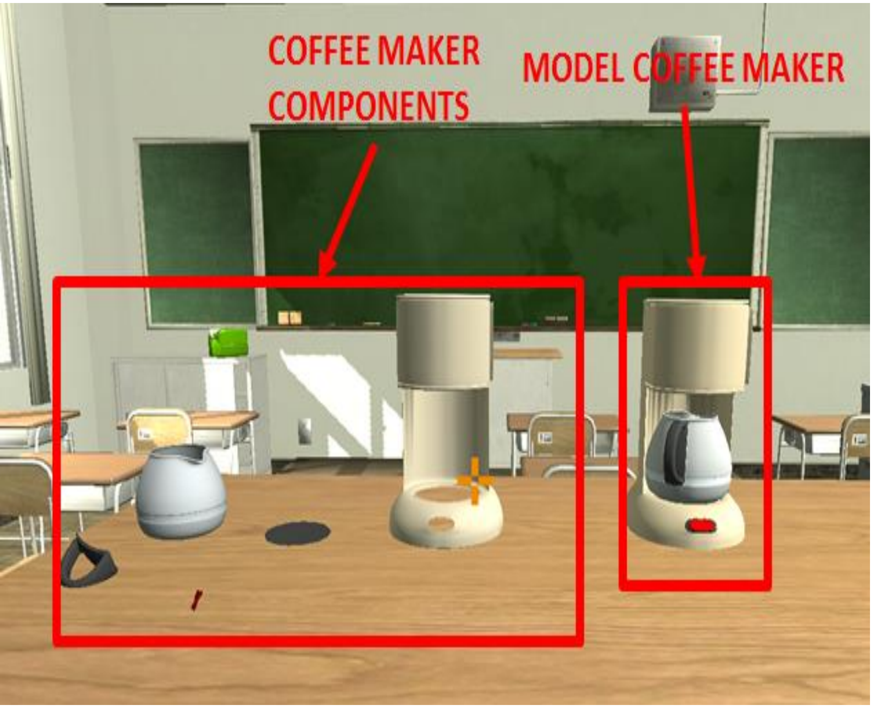


Astronomy

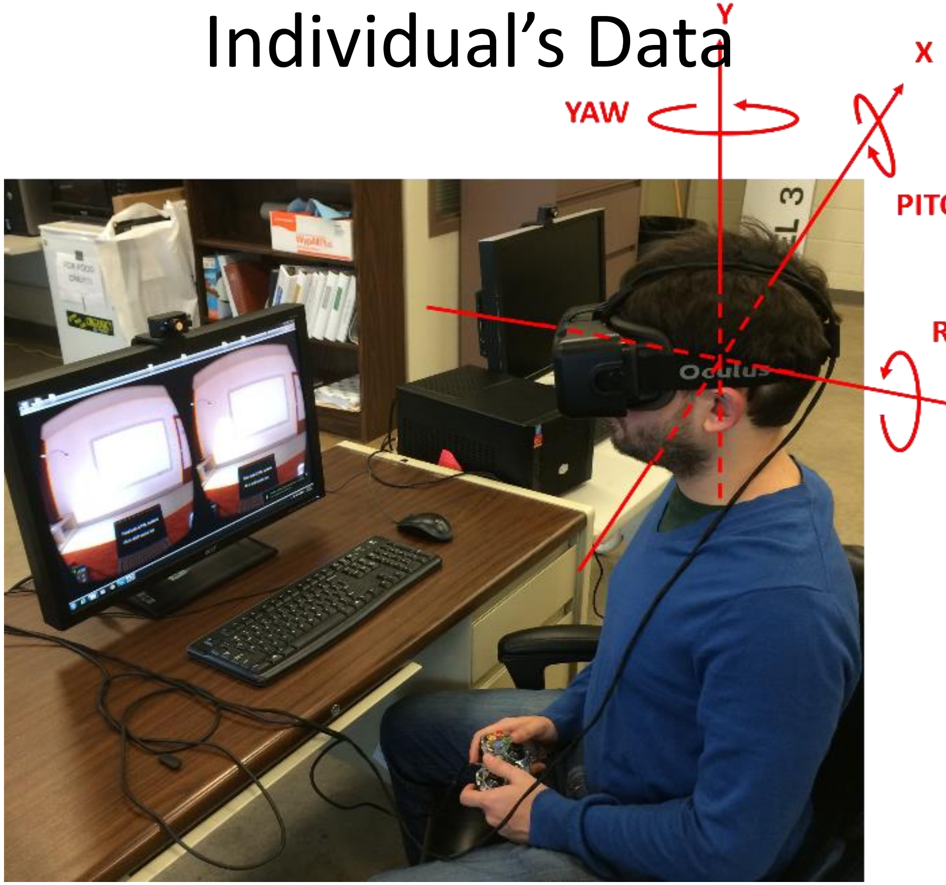


Data Mining Driven Design

Environment Data



Individual's Data



Conclusion and Future Work

- Performance outcomes of the students using immersive VR systems are significantly better than students using non-immersive VR systems
- Future work
  - Integration of 3D interactive technology with immersive visual displays
  - Effectiveness of immersive VR systems among users of different gender and age group
  - Extension of immersive VR systems to MOOCs

Acknowledgement & References

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(The Pennsylvania State University)

References

[1] Moshell, J.M., Hughes, C.E., 2002. Virtual environments as a tool for academic learning. Handbook of virtual environments: Design, implementation, and applications 893–910

[2] Tashiro, J.S., Dunlap, D., 2007, The impact of realism on learning engagement in educational games, in: Proceedings of the 2007 Conference on Future Play. ACM, pp. 113–120.

[3] Pantelidis, V.S., 1995. Reasons to use virtual reality in education. VR in the Schools 1 (1), 9.

[4] Çaliskan, O., 2011. Virtual field trips in education of earth and environmental sciences. Procedia-Social and Behavioral Sciences 15, 3239–3243.

[5] Ramasundaram, V., Grunwald, S., Mangeot, A., Comerford, N., Bliss, C., 2005. Development of an environmental virtual field laboratory. Computers & Education 45, 21–34.

References

Questions