proceedings

MDPI

Proceeding Paper

The Use of Disruptive Technologies in the Construction Industry: A Case Study to Compare 2D and VR Methods of Concrete Design Interpretation †

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† Presented at the Digital Transformation in Business: Challenges and New Opportunities, West Mishref, Kuwait, 17 November 2022.

Abstract: The laggard integration of digital technologies in the construction industry has seen to delay the sector in realizing its potential advantages. Using Virtual reality (VR) in the construction has the capacity to augment the interpretation of structural drawings. Comparing VR using head mounted display (HMD) devices with traditional 2D drawings in identifying structural mistakes in construction drawings has been conducted with engineering students enrolled in a concrete structures course. The findings show that the HMD VR group was able to identify 40% more mistakes in comparison to the traditional group in addition to the increase in efficiency and speed of detection of five minutes. The use of VR within engineering education can potentially increase the pace of digital technology's adaption in the construction sector.

Keywords: AutoDesk Revit®; construction delays; performance; virtual reality (VR); construction industry

Citation: Al-Khiami, M.I.; Jaeger, M.; Soleimani, S.M. The Use of Disruptive Technologies in the Construction Industry: A Case Study to Compare 2D and VR Methods of Concrete Design Interpretation. *Proceedings* **2023**, *85*, 1. https://doi.org/10.3390/proceedings2023085001

Academic Editor: Farid Abdallah

Published: 1 March 2023

1. Objectives

The construction industry has been diagnosed with low productivity rates and continuous project delays. Additional costs are accompanied by delays, resulting in construction projects exceeding the anticipated budget and time assigned [1]. The construction project design complexity level has been shown to have a considerable impact on project delays [2]. This project aims to integrate the use of VR in engineering education to improve the interpretation and understanding of construction designs.

2. Methodology

Using Autodesk Revit® (Newton, MA, USA), a concrete structure was designed based on engineering best practices. The design was modified by incorporating 12 different structural mistakes and was transferred into a Plugin, namely Enscape® (Karlsruhe, Germany), as shown in Figure 1. The software is compatible with virtual reality head-mounted display sets.

Students were divided into two groups: 2D and VR. Both groups were asked to identify as many mistakes as possible in 15 minutes using 2D plans and Oculus Quest 2 (HMD).

Both groups completed the assessment in an exam-like environment.

Figure 1. 3D model in Enscape®.

3. Results

Table 1 shows the results of the students' assessment.

Table 1. Students' performance results.

		Average Identified Mistakes	Average Unidentified Mistakes (Out of 12)	Average Wrongly Identified Mistake Category *	Average Time
2D N = 11	Average	2.45	9.55	2.91	15:00
	%	20.45	79.55	-	
	SD	1.67	1.67	1.24	
VR N = 10	Average	7.50	4.50	2.50	9:20
	%	62.50	37.50	-	
	SD	2.54	2.54	0.81	

* Wrongly identified mistakes refer to mistakes identified by students that are structurally accepted.

Students of the VR group found 62.5% of the mistakes, in comparison to the 2D group, who identified only 20.45% of the mistakes. The results prove the effectiveness of VR in comparison to 2D plans.

4. Implications

Confirming what was mentioned by [3–5], the results show that students are better prepared for the workplace when utilizing VR in their studies. It contributes to cost reduction and productivity improvements in construction companies.

The construction industry is advised to integrate digital technologies such as VR to reduce misinterpretations of 2D plans and improve their firms' overall performance.

5. Originality Value

The value of this research lies within its methodology and uniqueness in the Gulf Cooperation Council (GCC) region. The experimental research design with an experimental (VR) and a control group (2D) allowed us to draw reliable conclusions. Three main performance indicators were used: correctly identified mistakes, wrongly identified mistakes, and students' time taken for identifying structural mistakes. This approach is original and has not been applied previously.

Furthermore, no similar investigations have been carried out among students in the GCC region. Therefore, the results are also interesting from an educational point of view.

6. Contribution

This research provides evidence that the use of VR in engineering education has positively influenced students' performance, improved their interpretation skills, and increased their efficiency.

The use of VR can be integrated into the architecture, engineering, and construction (AEC) industry so it can further benefit from these advantages. It is crucial to consider VR in complex projects, as companies' competitiveness lies within their ability to reduce the level of complexity.

An improved understanding of the construction project also reduces the chance of project delays.

Author Contributions: Conceptualization, M.I.A.-K.; methodology, M.I.A.-K., M.J. and S.M.S.; validation M.I.A.-K., M.J. and S.M.S.; formal analysis, M.I.A.-K., M.J. and S.M.S.; writing—original draft preparation, M.I.A.-K.; writing—review and editing, M.J. and S.M.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data is available upon the request and approval of the authors.

Conflicts of Interest: The authors declare no conflict of interest.

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