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VIRTUAL GO GREEN: CONFERENCE AND PUBLICATION

"Rethinking Built Environment: Towards a Sustainable Future"

Organiser:
Research, Industrial Linkages, Community & Alumni Network (PJIM&A)

Co-organiser:
Department of Built Environment Studies & Technology (JABT), Faculty of Architecture, Planning & Surveying (FSPU)

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Potential of Virtual Reality Implementation in New Era Construction

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Abstract
Construction management software is among the latest trends in the new era of construction. Virtual Reality (VR) is largely used in the healthcare industry and the gaming sector is now considered as one of the fresh and new software introduced in the construction industry. Many construction companies are slowly learning the importance of its implementation to cope with the current trend. VR is such an immersive and interactive visualization in the process of design, engineering, construction, and management. Its advanced capabilities facilitate the interpretation of drawings produced by civil engineers and architects. It is found to be beneficial to the industry. Hence, the objective of this paper is to gain an in-depth understanding on the potential of VR implementation in construction practices. A questionnaire survey was distributed to the contractors' companies and data was analysed statistically. The findings of the study found that VR contributes a good potential in increasing the client's satisfaction, improving the quality of construction project as well as enhancing the safety for training. This study contributes to the body of knowledge in identifying the potential of VR technology in terms of promoting VR implementation for the construction industry.

Keywords: *Virtual Reality; Potential; Implementation*; *Construction*

1.0 Introduction

Many of the construction industry issues are directly linked to the failure of construction professionals to visualize the project before it is completed. This failure causes costly problems and in some cases, work must be stopped or delayed as the construction teams have made mistakes that cannot be seen on paper. Generally, instead of immersive technology, construction professionals must use a flat 3D model to visualize how the finished project will be in line with the original designs when it is completed. Indeed, VR can assist professionals in any industry, but particularly those in the construction industry, with an incredible device that lets them immerse themselves in a project before spending years building it. As stated by Le et al. (2015), development in the use of virtual reality (VR) technology to improve the quality of construction has been promoted in recent years. It is supported by Wang et al. (2018), Virtual Reality (VR) innovations have quickly emerged in construction engineering education and training programs, apparently to improve the quality of the plan's layout. Virtual reality is a shared virtual environment that leads to better decision-making. This paper is organized by providing the background of the study and the methodology used to conduct the study. It is followed by the results and discussion section. Finally, by providing the conclusion of the study.

2.0 Literature Review

According to Whyte & Bouchlaghem (1998), Virtual Reality (VR) in the construction industry has been used for design applications, interactive simulation and as a tool to improve construction processes. It is a system that merges the use of 2D drawings and 3D models on-site in a Virtual Reality context to help contractors interpret 2D drawings created by civil engineers and architects. By

simulating as many senses as possible, such as vision, hearing, and touch, the device is transformed into a facilitator and gives great potential in the construction industry in terms of time, cost and quality.

2.1 Time

The top advantage of using VR is the opportunity to see how the elements fit on the platform. It allows project managers to see if anything works on-site to scale before the supplies are ordered or the amount of work required for installation. According to Thabet et al. (2002), the use of 3D and VR can help if detailed design drawings could be created at an early stage of the conceptual design process. Workers would be able to tap and automatically measure designed parts and compare them to the model's dimensions while wearing wearables on-site. On-site revision allows the detection of the defect in design and reduces high costs and delays by rapid adaptation of adjustment.

One of the most common causes of an unfinished project is the design of projects that can cost a lot of money and delay, depending on the project's complexity (Avhad & Hinge, 2017). Virtual project simulation allows an up-to-date view of the worksite conditions. This method reduces the need for rework. Minor changes to the job site can also cause rework to delay completion by days or weeks. VR creates 3D models that allow management to see where changes are made and reduce rework. Hands-free, immersive VR glasses or goggles that overlay virtual plans into actual physical space may be used by builders or managers to enable the precise installation and placement of components that are critical to prevent conventional failures.

It is not only critical for construction workers to be present on the construction site, managers and supervisors must also keep a close eye on the project. A visit to the site may benefit other influential team members, such as architects, designers, and even shareholders or company leaders. VR allows them to analyze the project without having to be at the actual location. If an issue arises during development, it can be resolved in a shorter time. Instead of delaying progress for hours or even days while the manager travels to the site, the appropriate manager can quickly deploy a VR headset, assess the problem and provide a solution. Only by reducing the number of visits to the site can they achieve maximum efficiency, allowing them to work on multiple projects at once.

The use of VR in construction eases the flow of works in project planning. Using VR allows companies the opportunity to view the building more thoroughly. It offers companies the opportunity to display the finished building project at a very comprehensive level and how the structure can help or affect its surroundings. In the planning process of construction, it is crucial to ensure that the project design is compatible with the client's needs. By using virtual reality in combination with BIM, architects and design firms will fully showcase their clients' practical models. A combination of the 3D BIM model of the actual on-site project with the social VR system's safety data is suggested to solve the time-consuming and extra effort of contractor constraint and quantity surveyors during the pre-contract stage (Le et al., 2015).

According to Le et al. (2015), the construction industry is a dynamic environment in which high accident rates significantly contribute to cost overruns and time delays. Changes settled upon during construction can take from one day to several weeks to complete. Since there are fewer such adjustments, it is easier to predict deadlines. The development of technology in VR will help the construction industry reduce time delays and avoid time extension during the construction stage. With building projects facing delays, disruptions, and inability to complete due to the Coronavirus (COVID-19) pandemic, many are looking to their force maneuver coverage and delay provisions to decide what is deemed suitable for claim submission. Many building projects are delayed due to Covid-19 Pandemic during the Movement Control Order (MCO) in Malaysia. With virtual reality presentation, delays can be minimized so designers and architects can do a little bit of their work in design using the VR visual.

2.2 Cost

The cost of the construction project will also be reduced by using virtual reality (VR). Workers may also use this virtual reality interface to make decisions on a variety of issues that occur during the session, including problems that directly affect the flow of the scenario and affect the cost expense of

the project (Goulding et al., 2012). Allowing a better pre-planning stage, where a 3D model can be explored in VR, will reduce rework correlated with problems that are difficult to predict or arise from misunderstandings, which will impact the project's cost.

VR in construction offers many different advantages and opportunities, such as opening virtual doors for people to visit the VR site before even one brick is laid down. VR has detailed input from the finished project. Simultaneously, the designs are only being drawn up. The plans can be an essential addition to the building, mainly when they can significantly save time and costs in the future. From the early stages of construction to the building's maintenance after completion, modern technology enables users to understand what they see from every viewpoint fully. VR and other similar innovations may have a digital advantage where conventional media are unable to do so. Before consumers can be confident of their investments, outcomes can be less surprising and more rewarding for everyone.

2.3 Quality

As stated by Le et al. (2015), development in the use of virtual reality (VR) technology to improve the quality of construction has been promoted in recent years. It is supported by Wang et al. (2018), VR innovations have quickly emerged in construction engineering education and training programs, apparently to improve the quality of the plan's layout. VR is a shared virtual environment that leads to better decision-making. Since there are almost no misinterpretations, accuracy instantly increases, and the number of rework requests drops drastically.

VR could improve the design process, communication between contractors and clients, boost loyalty, and differentiate the company from competitors that can help to enhance the building quality. As more businesses understand the advantages of incorporating VR with their construction business, they expect these use cases to expand in new and exciting ways. Current technologies and processes used to deliver such activities in Malaysia have be insufficient to communicate and resolve the increased complexity of projects and incessant market demand for shorter construction time-scales (Ali & Nor, 2012).

As stated by Zhao & Lucas (2015), errors in the development of buildings cannot be prevented. Still, opportunities for error can be decreased by conducting proper and appropriate training using virtual reality that can reduce human error. Construction industry professionals know how easily an error can put a stop to a site. VR helps contractors investigate the future and spot mistakes before the plans are made and fixed before the construction crew begins to construct. Small details may be obtained that may be missed in the conventional computer-aided design (CAD) model or the Building Information Modeling (BIM) model.

Safety and inspection of workers can also be determined by using VR technology. Safety training using VR could prevent many human tragedies. A simulated construction site could show how and where to use safety precautions. A simulation could also show the site's progress at any given date. In terms of protection, wearables such as glasses are used as safety equipment and as inspection equipment for virtual reality. Part of the construction company uses virtual reality technology to improve job site operations to help construction inspectors save time, reduce costs, and increase safety. According to Le et al. (2015), accidents are significant problems that often occur in the construction process, as many studies have shown that accidents cause cost overruns and time delays. The inspection process is typically carried out manually and often involves more than one person. The surveyor will precisely align and compare the as-built structures with the BIM model. The surveyor can take photos on request or retrieve notes from location sites. On-site, challenging areas and critical problems are made easier to grasp, identify and share immediately.

VR can improve the protection training for the workers. In virtual reality's environment, workers can make as many mistakes as they need to operate dangerous equipment without damaging or destructing the machinery. VR can be used to train employees in the construction industry. Machine operators will begin practicing in a controlled environment before the worksite is ready if they have never used a specific machine or if they require a revision. Zhao & Lucas (2015) stated that a VR simulation-based safety training software will provide an engaging and interactive tool for training all construction employees on electrical hazards and safe working procedures. Successful training is

expected to improve and expand the effect of machinery and labor on the industry by addressing and meeting diverse stakeholders' needs. Construction workers and equipment operators require a great deal of training, practical guidance and information on industry rules and regulations before they can operate any piece of equipment. For example, a forklift training and certification company should have VR training programs that allow trainees to work in a simple and safe environment. It decreases the risk of injury and damage to the equipment while at the same time allowing for trial and error.

Table 3.1. The Potential of Virtual Reality (VR) highlighted by previous researchers.

Author	Potential of Virtual Reality in the Construction Industry
(Whyte et al., 2000)	VR can be used in construction and building-related research for design applications, collaborative visualization as a tool to improve construction processes.
(Issa, 2000)	VR can play a key role in developing a human-computer interface for an environment that uses immersive or non-immersive techniques to allow users to visualize design and construction information in 3D, photo-realistic, and interactive images.
(Zhao & Lucas, 2015)	VR simulations have been successfully used for safety training in the construction industry, allowing the user to connect with a virtual 3D environment that effectively visualizes invisible electrical hazards without putting at risk workers in real life.
(Goulding et al., 2012)	The use of an immersive VR training environment will also allow learners to experience training objectives, facilitate learning transfer, and accelerate learning in the construction industry.
(Le et al., 2015)	VR has enough potential to enhance the protection of experiential learning, the detection of potential workplace hazards, and worker danger awareness.
(Gigante, 1993)	VR can enhance workers' quality of life in dangerous or uncomfortable conditions and can ultimately influence society.
(Ali & Nor, 2012)	VR is a very promising planning tool in our existing project control activities and is expected to help our construction industry minimize or at least reduce the expected delay.
(Avhad & Hinge, 2017)	Virtual Reality technology is a complement to building technology, offering users a real-time view of what is going on before them.
(Thabet et al., 2002)	VR is a real interaction that can occur in all aspects of the virtual domain.
(Haggard, 2017)	VR has shown to be an efficient use of interdisciplinary technology

3.0 Methodology

This research was conducted by quantitative method with the distribution of questionnaires. The respondents are contractors registered with the Construction Industry Development Board (CIDB) under Grade 7. The questionnaire was distributed to the respondents in Kuala Lumpur. A total of 243 question aires was distributed as the sample of the population by referring to Isaac & Michael (1982). The items included in the questionnaire are divided into two sections which are Section A on respondents' demographic and Section B are questions on the benefits of the VR implementation in the construction industry. The questions included in the demographic section are the respondent's gender, job category, work experience, higher academic qualifications, and the participation of the respondent in the green building project. The purpose of this segment is to examine the demographic history of the respondents. Section B consists of questions related to the benefits of VR in construction as listed according to the previous research. The objective of this section is to analyze the respondents' perception and knowledge towards the rising technology, which is VR implementation in the Malaysian construction industry. The items were measured on a five-point Likert Scale where 1 indicated strong disagreement and 5 indicated strong agreement with the item. All data collected was analysed by using Statistical Package for Social Sciences (SPSS) software and tabulated systematically.

4.0 Results

This section examines the potential of implementing virtual reality in various ways in the construction industry.

Table 4.1. The Potential of Virtual Reality (VR) Implementation in Malaysia.

Description	Mean	Perception Level	Rank
Increase customer satisfaction	4.10	Agree	1
Improves quality of construction project	4.07	Agree	2
Enhance safety for training	4.07	Agree	3
Reduce information loss in data exchange	4.04	Agree	4
Lower the delays on the construction period	4.03	Agree	5
Identification of potential structural collapse	3.99	Agree	6
Real-time and quick checking of safety and unsafe working condition	3.99	Agree	7
Reduce labour cost	3.96	Agree	8
Less rework of the project	3.94	Agree	9
Better monitoring of the dynamic environment	3.92	Agree	10
Reduce manpower required for safety on site	3.86	Agree	11
Lower the cost of construction project	3.58	Agree	12

From Table 4.1, it is apparent that there is a list of advantages of VR implementation in the Malaysian construction industry. 'Increase customer satisfaction (mean=4.10) has been found as the main advantages of VR in construction and followed by 'improves the quality of construction project' (mean=4.07) and 'Enhance safety for training' (mean=4.07). Meanwhile, the mean score for 'Reduce information loss in data exchange' is 4.04 and 'Lower the delays on construction period' is 4.03. 'Identification of potential structural collapse' and 'Real-time and quick checking of safety and unsafe working condition' is sharing the same Mean, which is 3.99. 'Reduce labor cost' and 'Less rework of the project' are both slightly different (mean=3.96) and (mean=3.94). However, 'Better monitoring of dynamic environment', 'Reduced manpower required for safety on site' and 'Lower the cost of construction project' indicated the lowest mean score of the factors as 3.92, 3.86 and 3.58 respectively.

As a result, it is found that the main advantage of implementing Virtual Reality in Malaysia, agreed by the respondent, is to increase customer satisfaction. Customer satisfaction is essential to achieve maximum profit as the customer knows how the project will be built This statement is supported by Ali & Nor (2012), which stated that VR gave satisfaction to the client who expected to have a 3D view of the planned building that allows construction professionals to walk through the building model. Improving the quality of construction projects took second place for the advantages of implementing VR in this study analysis. As stated by Whisker et al., 2020, VR offers a high-quality virtual display system that will improve the quality of construction for buildings. VR innovations have quickly emerged in construction engineering education and training programs because they are expected to improve the building plan's design quality. Other than that, enhancing safety for training is one of the significant advantages that are agreed by the respondents in the implementation of VR in Malaysia. According to Zhao & Lucas (2015), VR is needed to avoid injury due to hazards when training on a construction site. VR provides a better training environment as trainers can operate with massive machines with reduced risk of injury. Generally, results of advantages of Virtual Reality implementation in this research had shown positive feedback from the respondents and also supported by the previous researchers.

5.0 Conclusion

Previous research has shown that interpretation errors have happened during design and construction stages and these have resulted in poor quality of construction, cost overruns and schedule delays. Overall, virtual reality (VR) has great potential to overcome these problems. It simplifies the

complicated documentation process which is known as costly and time-consuming using technology. It improves the overall process of management, training and construction process. While the construction industry has taken great steps forward with better hardware and software on the way, the future is dynamic with opportunities for those organisations embracing a non-traditional approach with the adoption of VR technology. VR acceptance will continuously grow and will extensively and positively impact construction in the coming years.

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