

TECHNOLOGY ACCEPTANCE MODEL FOR BUILDING INFORMATION MODELLING BASED VIRTUAL REALITY (BIM-VR) IN COST ESTIMATION

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SUMMARY: The accuracy of cost estimation during the preliminary stage of a construction project is imperative. However, owing to limited accessibility of information, the level of accuracy required at this stage of a project is extremely difficult to be attained. In like manner, the risks of budget shortages or cost overruns are likely to surge exponentially due to an incompetent or a lackadaisical approach towards life-cycle costing. Hence, this study proposes BIM-based VR as a preliminary estimating solution which is purported to nip the aforementioned issues in the bud. BIM-VR enables BQ to be updated automatically as stakeholders performs modifications on-the-go, allowing speedy and highly accurate design adjustments throughout the project. On this front, the Technology Acceptance Model (TAM) was adopted to determine the acceptance level of BIM-based VR technology in Malaysia. Data was acquired via a questionnaire survey, of which 92 out of 180 distributions were accepted for analysis, accounting to a respectable response rate of 51%. Consequentially, Principal Component Analysis result revealed that 'Saving Cost and Resources' is the most significant factor for BIM acceptance. Conversely, 'Presence of Skill Gap' was found to be the biggest stumbling block for BIM-based VR in cost estimation. Relationship analysis from the TAM also unveiled that the challenges of BIM-based VR did not produce mediating effect towards attitude and intention to use. This implies that the intention of construction professionals to adopt the technology wasn't impeded by its challenges. Significantly, this study served as a benchmark in uncovering new possibilities of BIM and VR in project cost management, where the reliability and accuracy of conventional procurement can be enhanced with technology, particularly in BQ documentation, to fulfill the rising expectations of construction stakeholders across the globe.

KEYWORDS: *Cost Estimation, Building Information Modelling, Virtual Reality, Technology Acceptance Model*

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1. INTRODUCTION

Poor cost estimation has always been a critical issue in the construction industry today due to the highly complex nature of projects. The high level of dynamism and complexity has ultimately contributed to the escalated uncertainty in the construction projects. The high level of uncertainty would eventually drive the projects towards more problems such as cost overruns (Aljohani, Ahiaga-Dagbui, Dominic and Moore, 2017). Cost overrun is one of the most common concerns in construction projects (Memon, Rahman and Azis, 2011). This trend is especially pronounced in developing countries, where cost overruns can potentially surpass 100% of the initial budget (Memon, Rahman and Azis, 2011). The most common instances would be the oversights and misunderstandings that happened only during the construction stage, resulting in rework and additional costs. Next, B/Q is also very prone to human error because the tasks are generated manually. Estimators regularly make obsolete errors such as omissions, double-counting, and misusing outdated drawings. Hence, BIM is introduced to streamline the collaboration between construction professionals and provide a reliable and efficient quantity take-off.

Building Information Modelling (BIM) is a sophisticated digital information management system that can help facilitate projects with processes and information distribution. In terms of cost estimation, BIM can help to reduce significant amount of time and cost of estimators. This can be done as the construction materials, quantities and properties can be easily retrieved from BIM. Then, the information is linked to the cost estimation database to estimate the overall project cost (Ramaji *et al.*, 2018). Despite providing many benefits in doing cost estimation, BIM alone does not offer immersive visualization. With that, it resulted in problems like oversight and misunderstanding of elements when performing quantity take-off (Davidson *et al.*, 2019). Hence, VR is proposed to offer immersive visualization in a 1:1 scale.

Virtual Reality (VR) is incorporated into BIM workflow to mainly assist in immersive visualization and provide alternative solutions in the early stage and eliminate construction discrepancies. VR can overcome misunderstandings and oversight issues by providing a realistic representation of elements such as interior finishes, carpentry, and ironmongery, which clients often find hard to visualize. VR enables clients to recommend modifications to the design before being quantified into the final B/Q. This enhances the document's accuracy by precisely reflecting the client's expectations in a project. Next, it would also eliminate last-minute changes, which could lead to additional expenses (Ahmed, 2020).

Numerous models can be utilized to develop BIM-based VR solutions, and the adoption rate has been increasing recently as more construction professionals are beginning to accept the new change. Most of recent BIM-based VR studies are mainly related to a particular application level; however, only a handful of studies were carried out on the issues related to the successful implementation of BIM-based VR integration. Little research has been done to investigate how the construction sector accepts and implements BIM-based VR into its operations. Hence, this study aims to fill the missing gap by building a TAM for BIM-based VR in cost estimation. The findings are significant as future researchers could use them to identify future directions and discover research possibilities. Next, the discovered factors such as PEU and PU will benefit the construction industry while adopting or developing the new BIM-based VR platform. This study aims at enhancing the cost estimation through the usage of BIM-based VR in construction industry. The objectives of this study are to identify the potential benefits of BIM-based cost estimation, examine the challenges of BIM-based VR in cost estimation and to develop a TAM for BIM-based VR integration in cost estimation.

2. LITERATURE REVIEW

2.1 Conventional Cost Estimation

The goal of cost estimation is to evaluate a project's feasibility and provide a comprehensive budgeting plan. Generally, project cost estimation can be categorized into two categories: preliminary estimates and detailed estimates (Lee *et al.*, 2020). The preliminary estimate is performed during the initial phase, where the design information and time are limited to generate a precise estimate. In contrast, a detailed estimate is performed between the execution and closure phase, which naturally results in more accurate forecasts as the drawings have all been finalized. Hence, this study suggests focusing on implementing BIM-based VR from the initial phase of a construction project to spot and rectify all the costly mistakes from the start.

