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The Intervening Role of Perceived Ease of Use and Perceived Usefulness on the relationship between Information Quality, System Quality, Service Quality and Building Information Model（BIM) User Satisfaction in China

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Abstract

The development of informatization is the main task of the transformation and upgrading of the construction industry. As a representative technology of informatization, Building Information Modeling (BIM) is widely believed to help solve the problems of traditional construction industry and improve the efficiency of engineering projects. In recent years, more and more enterprises have adopted BIM technology, which is not only applied to construction engineering, but also expanded to highway engineering, rail transit engineering, airport engineering and so on. In the era of big data, it is also combined with new technologies such as cloud technology, the Internet of Things, and RFID radio frequency identification, which broadens the application range of BIM technology. While paying attention to the BIM application field, the academic circles and the industry have also begun to pay attention to the user satisfaction during and after the implementation of BIM. Analyzing clearly what factors affect the satisfaction of BIM users, and how these factors affect each other, is directly related to the success or failure of BIM technical information system projects, and it is also a problem that researchers and business executives should pay more attention to. However, most of the existing research focuses on the technical application, organizational process and policy environment of BIM, and there are few studies on BIM users and their satisfaction. Based on the perspective of employees of BIM implementation companies in the field of construction engineering, this research will conduct research on the influencing factors of BIM user satisfaction and the mechanism of action between the factors from the perspective of users, so as to deeply understand the thoughts of users, improve the satisfaction of BIM users, and accelerate the development of BIM users. The pace of application of BIM.

Keywords: Building Information Modeling (BIM); User satisfaction; Influencing factors; Mechanism of action

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Introduction

The construction industry is gradually developing towards informationization, dataization and intelligence, and BIM technology has become an indispensable force in promoting development. With the application of BIM technology in the early planning, design, construction, operation and

maintenance stages, the whole life cycle data sharing and information management of engineering construction projects will be gradually realized. BIM is regarded as a next-generation solution that can improve the productivity of construction units, construction units and other relevant units in the construction industry and simplify the delivery process of construction projects. It has played a huge role in promoting the transformation and upgrading of the construction industry（Tingfeng, Z.， et al.,2022）.

However, the construction model and management methods of the traditional construction industry are backward, and there are problems such as large waste of resources, low labor efficiency, and poor quality and safety levels. There is still a large gap between the requirements for high-quality development (Yuan, et. al., 2023). In view of the outstanding problems faced by the construction industry, information technology provides new methods to solve problems in the construction field (Rezgui and Zarli, 2006). Building Information Model (BIM) is a technical tool and management concept developed based on modern information technology and a milestone in the field of engineering projects. It focuses on the parametric expression of relevant information of each stage and participant of the construction project. and integrated management (Wang, 2011). BIM technology is widely regarded by industry personnel and scholars as an important potential means to solve problems in the traditional construction industry and improve project efficiency. In order to embark on an intensive high-quality development path, China's construction industry urgently needs to deeply integrate with BIM technology.

Industry personnel and scholars widely agree that BIM technology can effectively improve the production efficiency and economic benefits of the construction industry (Barlish and Sullivan, 2012). However, in many actual projects, the application of BIM technology has not produced or even far below the expected effects and benefits. (Fischer and Kunz, 2004; Miettinen and Paavola, 2014), the recognition of BIM technology by investors and project participants is also uneven. As an information technology implemented by people, BIM's implementation effect is closely related to the user. The higher the BIM user satisfaction, the better the application effect and the more obvious the application value, which will contribute to the development of BIM technology. Successfully applied and promoted. Some scholars have regarded user satisfaction as a key evaluation indicator to measure the success or failure of BIM technology application (Wang et al, 2017) and promote the successful promotion of BIM technology (Rodgers et al, 2015). However, in recent years, academic research on BIM has mainly focused on the technical, organizational and environmental levels, and insufficient attention has been paid to BIM users and their satisfaction, which still needs further research.

Research Questions

This study looks at how Information Quality, System Quality, and Service Quality affect BIM User Satisfaction in Chinese construction companies, where there is still a dearth of information on the industry's history. The authors close some gaps in our knowledge of these interactions by examining the mediating and moderating impacts of perceived usefulness and perceived ease of use.

Therefore, this study raises the following questions:

1.What is the relationship between information Quality, System Quality, Service Quality and BIM User Satisfaction in construction enterprises in China?

2.Is Perceived Usefulness mediating between information Quality, System Quality, Service Quality and BIM User Satisfaction in construction enterprises in China?

3.Is Perceived Ease of Use moderate the relationship between information Quality, System Quality, Service Quality and BIM User Satisfaction in construction enterprises in China?

Research Objectives

The current study attempts to pinpoint the important facets of system, information, and service quality that influence BIM user satisfaction. The present study intends to bridge the knowledge gaps

in practise, industry, and theory by examining the relationship between Information Quality, System Quality, Service Quality, and BIM User Satisfaction in Chinese construction businesses.

1.To examine the relationship between information Quality, System Quality, Service Quality and BIM User Satisfaction in construction enterprises in China.

2.To examine the mediating role of Perceived Usefulness between information Quality, System Quality, Service Quality in construction enterprises in China.

3.To examine the moderate role of Perceived Ease of Use between information Quality, System Quality and Service Quality and BIM User Satisfaction in construction enterprises in China.

Scope of the Study

Data from a random sample of employees in Chinese construction enterprises will be a major source of information for this study. The study's participants were Chinese construction industry employees. A questionnaire survey was used in this investigation. Target firms will get computerised questionnaires as part of the data collection process. Subsequent research endeavours may gather information from additional Chinese provinces and ultimately extrapolate the findings to the entirety of China. Information quality, system quality, service quality, perceived ease of use, and BIM user satisfaction are the only topics covered in this study. This could be detrimental since unassessed variables could have an impact on the outcomes.

Significance of the Study

At present, BIM research mainly focuses on model creation methods, BIM application expansion, BIM implementation success evaluation, organizational change and BIM policies, etc. There are few studies on BIM user level. This paper starts from the perspective of employees of BIM implementation enterprises in the field of construction engineering, to analyze the promotion effect of BIM users and their satisfaction on BIM application effect and usage behavior. Supplement the existing BIM-related research content and achievements from the academic level.

Research on BIM influencing factors mainly focuses on adoption and application barriers, while this study focuses on BIM users and their satisfaction with use, and explores the main factors affecting BIM user satisfaction, which is an extension of the existing research on BIM influencing factors.

There are few related studies on BIM user satisfaction, and this field is still in its infancy, lacking systematic theoretical research. Based on the existing BIM user satisfaction research, combined with the relevant theories of information technology satisfaction research, this paper explores the internal and external causes of BIM user satisfaction and conducts research on the impact mechanism of BIM user satisfaction. It not only enriches the research content of BIM user satisfaction, but also expands the application fields of user satisfaction related theories. At the same time, it also provides some theoretical guidance for scholars to carry out related research on BIM user satisfaction.

With the introduction of BIM into China, various BIM theories began to improve rapidly, but there are still many problems that have not been fundamentally resolved, such as the stability, speed, accuracy and compatibility of BIM tools, and many details to be improved. The expectation is that the developer will provide the software with the best performance. For the developers of BIM technology, in order to win the market, they should understand the real feelings of users and understand the ideas of users. They should focus on the needs of users to carry out product development and improve related functions, so as to improve user satisfaction. This study analyzes the impact mechanism of BIM technology satisfaction and puts forward targeted suggestions, and takes measures to improve the product in advance before developers push their products to the market, enhance user experience, and achieve better development of enterprises.

The promotion of BIM technology in the construction industry is hindered, and the application of BIM technology has no significant effect in improving the benefits of the construction industry. As one of the driving forces to promote BIM, BIM users have a non-negligible impact on

the successful implementation of BIM. This paper studies the user satisfaction of BIM as a factor affecting the promotion of BIM technology from the perspective of users. This research will help to promote the better and faster development of BIM technology construction industry.

Literature Review

This chapter's review of the literature is based on material from multiple databases, including Science Direct, Scopus, and Proquest. This study's primary focus is on terms like perceived usefulness, perceived simplicity of use, information quality, quality of quality, service management, and BIM user happiness.

BIM User Satisfaction

The goal of Halmetoja's (2019) research is to explain how big data and building information modelling (BIM) may be integrated into a single interface to offer property owners, users, and enterprises that provide workplace and property services new value. By utilising virtual reality (VR) and building information modelling (BIM) technologies, (Wong et al., 2019) seeks to create a real-time interactive lighting design technique that enhances lighting design visualisation and boosts design efficiency. For small and medium-sized businesses (SMEs), (Yoo et al., 2019) suggested a prefabricated steel frame building technology based on BIM. (Kwon et al., 2019) sought to ascertain the impact of thermal comfort and visual comfort on user satisfaction in relation to one's level of personal control over indoor environmental conditions.

The BIM-based space management system in the operation and maintenance stages of educational office buildings was investigated by (Ma et al., 2019). Based on BIM, a system called Building Information Modelling Space Management (BIMSM) is suggested. The emphasis of (Theißen et al., 2020) is on automatically creating basic plans and digitally documenting demand planning. Using the online education platform in China as the research subject, Chen et al. (2020) created customer satisfaction indicators by examining feelings and previous research in addition to using web crawlers and surveys to gather online and offline user experience data. In order to forecast user pleasure, a BP neural network model was built after a quantitative analysis of the system. According to Jiang et al. (2021), 39 project instances utilising BIM technology were utilised as a baseline sample for the fsQCA (fuzzy set qualitative comparative analysis) approach, which was used to enhance the study outcomes of BIM user satisfaction and give reference solutions for engineering practise. The relationship between user pleasure and performance. This is a consensus process model for multi-party cooperation, interest balance, lossless transmission of construction information, responsibility traceability, and customer satisfaction. (Ni et al., 2021) analysed the development and promotion of blockchain technology in construction projects from the perspective of new technologies and the entire life cycle, and proposed the integration points of BIM and blockchain technology: multi-user, multi-stage, multi-objective data fusion and traceabili A study by Hajesmaeel-Gohari et al. (2021) attempted to review the most popular questionnaires used to evaluate telemedicine services and capture Aspects of telemedicine assessment they cover. Selecting a suitable questionnaire for research purposes can be a difficult undertaking for researchers.

Although academics differ slightly in how they define or characterise satisfaction, they agree on the following two aspects of IT user satisfaction: A person's psychological responses to a particular piece of information technology make up their level of satisfaction, and these responses are influenced by a variety of circumstances unique to the individual. the result of internal and external influences working together. Project satisfaction and BIM user satisfaction are not the same things. In general, project success is closely correlated with project satisfaction, with cost, time, and quality serving as evaluation metrics. L. H. Nguyen (2019). In the case of BIM applications, the owner could believe that BIM has not produced the desired outcomes or met the necessary requirements even if the executing party completes all of the required content. et al., Jin (2017). Ma et al. (2020) examined how people behave after utilising BIM at varying degrees of pleasure, taking into account the idea of the "environment." The total of users' positive or negative responses to BIM

as a result of the combined influence of internal and external elements when using BIM technology is referred to in this study as BIM user satisfaction.

System Quality

A prefabricated steel frame construction approach based on BIM was presented by Yoo et al. (2019) from the viewpoint of small and medium-sized enterprises (SMEs). Alzahrani et al., (2019) investigated the use of the DeLone and McLean Information Systems Success Model for modelling the success of digital libraries. In order to do this, a research model that was explained as an empirical study was built utilising the information system success model developed by DeLone and McLean. A mobile catering application success model was created and verified by (Wang et al., 2019) using marketing literature and e-commerce system success models as a basis. The goal of (Santa et al., 2019) is to investigate how trust in online services affects user satisfaction with e-government services as well as other perceptions like the effectiveness of enterprise systems and the organization's operational efficiency in relation to e-government.

Empirical data elucidating the influence of work environment, IT system quality, and work culture on user satisfaction of PT XYZ accounting information system is the research object of (Mandala et al., 2019). The study conducted the following four tasks in order to meet the aforementioned objectives: first, it offered intelligent suggestion functions and visualisation to assist building managers and users in analysing and creating plans based on electrical equipment and space usage requirements; second, it used Internet of Things technology to reduce the discrepancy between the simulated and actual situations in the Building Information Model (BIM); third, it accurately assessed the comfort level of [Wu and others, 2019]. According to Shim et al. (2020), this study was carried out specifically within the National Health Information Portal (NHIP) in South Korea. Using the online education platform in China as the research subject, Chen et al. (2020) created customer satisfaction indicators by examining feelings and previous research in addition to using web crawlers and surveys to gather online and offline user experience data. In order to forecast user pleasure, a BP neural network model was built after a quantitative analysis of the system. A theoretical framework based on models and literature was put forth by Shahzad et al. (2020) to assess the effectiveness of e-learning portals.

Information Quality

A prefabricated steel frame construction approach based on BIM was presented by Yoo et al. (2019) from the viewpoint of small and medium-sized enterprises (SMEs). The goal of (Halmetoja, 2019) is to explain how big data and building information modelling (BIM) may be integrated into one interface to offer property owners, users, and enterprises that provide workplace and property services new value. (Alzahrani et al., 2019) investigated the use of the DeLone and McLean Information Systems Success Model for modelling the success of digital libraries. In order to do this, an empirical study was carried out and a research model was built utilising the information system success model developed by DeLone and McLean. The goal of (Santa et al., 2019) is to investigate how trust in online services affects user satisfaction with e-government services as well as other perceptions like the effectiveness of enterprise systems and the organization's operational efficiency in relation to e-government. A mobile catering application success model was created and verified by (Wang et al., 2019) using marketing literature and e-commerce system success models as a basis. The emphasis of (Theien et al., 2020) is on automatically creating basic plans and digitally documenting demand planning. According to Shim et al. (2020), this study was carried out specifically within the National Health Information Portal (NHIP) of South Korea.

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Service Quality

The goal of (Halmetoja, 2019) is to explain how big data and building information modelling (BIM) may be integrated into one interface to offer new value to stakeholders including owners, users, property services, and workplace service providers. Using the Delone and Mclean information system success models, (Alzahrani et al., 2019) investigated digital library success modelling. With this goal in mind, we utilise the information systems success model developed by Delone and McLean to create a research model that we interpret as an empirical study. A model explaining how users of mobile communication applications develop them intends to continue using the applications was created by combining the mobile service quality framework, inertia, and user happiness (Wang et al., 2019). A mobile catering application success model was created and verified by (Wang et al., 2019) using marketing literature and e-commerce system success models as a basis. The goal of (Santa et al., 2019) is to investigate how online service trust affects user satisfaction with e-government services as well as other views including the efficacy of e-G2B systems and organisational operations. (Sarkar et al., 2020) conducted a meta-analysis to examine the causes and effects of m-commerce trust. A meta-analysis of 118 pertinent empirical research was carried out for this investigation. Using different conceptions, (Raza et al., 2020) tried to investigate the structural relationship between online banking service quality, e-customer satisfaction, and e-customer loyalty. Apply quantitative techniques. A theoretical model was presented to show the effects of five online-to-offline service characteristics of dockless bicycle sharing on user satisfaction and behavioural intents, drawing on service quality theory (Shao et al., 2020). The National Health Information Portal (NHIP), a Korean government website providing health information, was the particular setting in which this study was carried out (Shim et al., 2020). A theoretical framework based on models and literature was put forth by Shahzad et al. (2020) to assess the effectiveness of e-learning portals.

Perceived usefulness

Ten theories were put up by (Rahardja et al., 2019) to look into the goals of this investigation. The primary objective of (Machdar, 2019) was to conduct an empirical investigation into the relationship between perceived utility, perceived ease of use, and information quality. Few studies have looked at user adoption of Building Information Modelling (BIM) technology, despite the fact that it is widely used in the construction sector and attracts user interest. The goal of (Park et al., 2019) was to present an acceptance model for BIM technologies and look into the ways that outside variables that were gleaned through in-depth interviews encourage the uptake of these technologies. The Technology Acceptance Model (TAM) and affinity theory, motivated by the success of information systems, were used by Xu et al. (2019) to investigate the distinctions and parallels between graduate and undergraduate students' contentment with digital libraries (DLs). A data set was gathered by (Liu et al., 2019) via a lab investigation in which participants had to finish a number of challenging search tasks. Using hierarchical linear models (HLM), Liu et al. (2019) attempted to elucidate the ways in which various cognitive impacts impact users' pleasure at the query and session levels. In 2020, Sarkar et al. conducted research on the effects of mobile a meta-analysis of the causes and effects of corporate trust. A meta-analysis of 118 pertinent empirical research was carried out for this investigation. Alkent et al. (2020) used this study, which focuses on trust, perceived utility, and customer happiness, as a reference to examine Instagram users who are known to use the platform to purchase and sell to fulfil their needs. (Shao et al., 2020) presented a theoretical model based on the service quality theory that illustrates the influence of five online-to-offline service attributes on user satisfaction and behavioural intentions of dockless bicycle sharing. A unique extended expectations-confirmation model was presented by (Gupta et al., 2020) to investigate the influence of previous adoption expectations and confirmations on subsequent satisfaction and continuance intentions. Al-Maroof et al. (2020) have made a contribution by putting forth a model of GC persistence intention.

Perceived Ease of Use

Comparative and psychological viewpoints that could affect the user's interaction with the vehicle have only been taken into consideration in a few number of research. Accordingly, factors influencing the use of autonomous vehicles (such as perceived risk, relative advantage, self-efficacy, and psychological ownership, or sense of ownership) were examined from the perspectives of the technology acceptance model (taking into account perceived ease of use, perceived usefulness, and intention to use) and autonomous vehicle use (Lee et al., 2019). Using the Extended Technology Acceptance Model (e-TAM), (Yalcin et al., 2019) sought to investigate students' acceptance of and intention to utilise learning management systems (LMS) in Turkish university education. The external construct was expanded upon by (Shrestha et al., 2019) to show how intentions to use blockchain-based systems are influenced by perceived usability, perceived enjoyment, perceived ease of use, and system quality. Dahleh (2019) Examining how visual analytics are being adopted by businesses using an integrated approach of task-technology fit and technology acceptance. There hasn't been much research done on what makes organisations adopt it. The goal of (Motamedi et al., 2019) was to create a user acceptance model for the shared use and personal ownership notions of full driving automation. By combining the Technology Acceptance Model (TAM) and the DeLone & McLean (D&M) Information Systems (IS) Success Model, a framework is put out to answer the study issue (Ullah et al., 2020). The goal of (Daoud et al., 2020) was to look at the variables affecting Jordanians' acceptance and usage of smart home services. Based on the integrated Technology Acceptance Model (TAM) and Theory of Planned Behaviour (TPB), the themes of (Kim et al., 2021) are to (1) provide clear insights into the determinants that drive students' greater willingness to use online learning systems, and (2) provide the moderating effect of innovativeness as a key factor. (Almaiah and others, 2022). Assessment report on a study to measure teacher quality, student constructs, satisfaction with TAM, and uncertainty avoidance effects in order to improve teacher effectiveness in the education sector. Linking the utilisation of digital data. Digital information experience as perceived in education (DIE). (Xu et al., 2023) investigated how users behaved differently while utilising chatbots and search engines to find information.

Research Framework

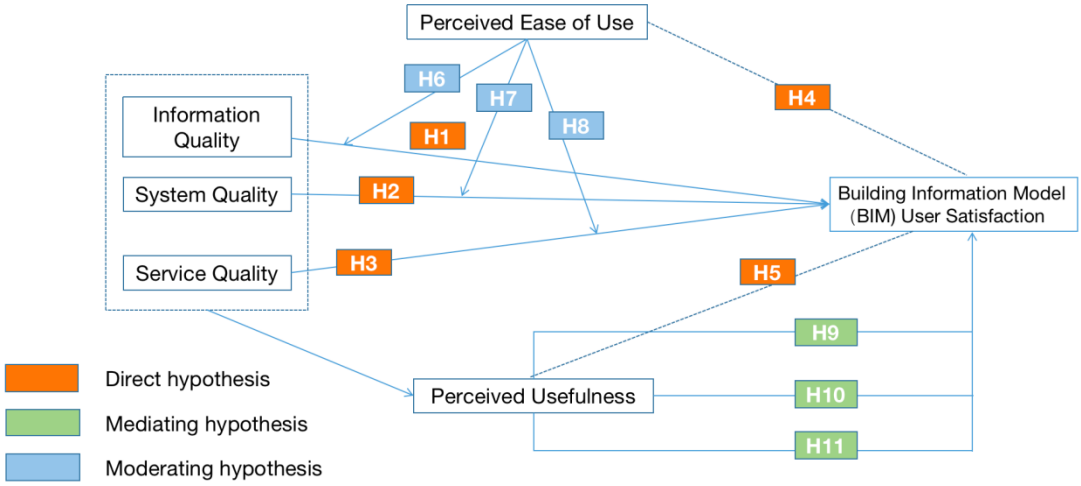

Figure 1 : Research Framework

Based on the literature discussion, this study proposes the following hypotheses:

H1: There is a significant relationship between Information Quality and BIM User Satisfaction

H2: There is a significant relationship between System Quality and BIM User Satisfaction

H3: There is a significant relationship between Service Quality and BIM User Satisfaction

H4: There is a significant correlation between Perceived Ease of Use and BIM User Satisfaction

H5. There is a significant correlation between Perceived Usefulness and BIM User Satisfaction

H6. Perceived Ease of Use has a moderating effect between Information Quality and BIM User Satisfaction
H7. Perceived Ease of Use has a moderating effect between System Quality and BIM User Satisfaction
H8. Perceived Ease of Use has a moderating effect between Service Quality and BIM User Satisfaction
H9: Perceived Usefulness has a mediating effect between Information Quality and BIM User Satisfaction
H10: Perceived Usefulness has a mediating effect between System Quality and BIM User Satisfaction
H11: Perceived Usefulness has a mediating effect between Service Quality and BIM User Satisfaction

Methodology

This study used a quantitative research approach and mostly collected data through questionnaires. The questionnaire was developed using statistical analysis and objective measurement, drawing on pertinent domestic and international studies on IS user satisfaction (van der Lippe & Lippényi, 2020). Because it makes it possible to evaluate correlations between variables using statistical techniques, a quantitative approach to research is ideal. This aligns with the primary objective of the research, which is to investigate the direct correlation between BIM user happiness, system quality, information quality, and service quality. In order to improve the accuracy of the analysis and findings, the study also made use of a sizable sample. Every respondent was given the same set of questions thanks to the research methodology.

Specifically, first, this article first retrieves a large number of relevant research literature from databases such as Scopus and Web of Science using different combinations of keywords such as BIM satisfaction, IS satisfaction, user satisfaction, and BIM. Using a review method, we preliminarily analyzed and sorted out multiple possible factors that affect BIM user satisfaction. Secondly, based on the first step, compile the influencing factors into a draft and send them to some experts in the professional field and practitioners in the industry, asking them to evaluate the importance of the relevant factors, and then based on the evaluation As a result, the list of influencing factors was re-analyzed and organized. Third, based on the second step, we invited experts in the professional field and people with rich BIM experience to conduct interviews, and asked them to conduct an overall analysis and evaluation of the influencing factors obtained in the second step. After that, after further sorting and analysis, a scale of factors influencing BIM user satisfaction was finally formed. Finally, on this basis, through discussions with several doctoral students in the research group, the structure and content of the scale and questionnaire were carefully revised many times, and the final scale and questionnaire were determined. The questionnaire mainly includes three parts: personal background information, factors affecting BIM user satisfaction, and BIM user satisfaction.

Dwivedi et al. (2019) state that the goal of investigative approaches is to elucidate phenomena and determine the underlying causes of any given behaviour. In addition, obtaining information from a large number of respondents is a practical approach for researchers to use survey techniques (Dwivedi et al., 2019). Data for the current study were gathered by a quantitative questionnaire. Creswell (2009) states that quantitative research is predicated on the assessment of social and humanistic problems, which entails putting a theory to the test using numerically measurable variables and then applying statistical techniques to determine whether the theory's predictions are accurate.

The majority of the time, questionnaires are given via Questionnaire Star to construction engineering practitioners that have worked in the field for more than six months and are involved with BIM technology. We obtained legitimate questionnaires by first examining the questionnaire and removing those that had clear consistent responses and missing important values. This study's quantitative method is acceptable since it makes use of statistical techniques to evaluate the

relationships between the variables. This aligns with the primary goals of the research, which include establishing clear connections between perceived utility, perceived ease of use, information quality, system quality, and BIM user happiness. Furthermore, a sizable sample size was employed in this study in order to improve the accuracy of the analysis and findings. Every responder was given the same set of questions to answer thanks to the research methodology. The significance of learning how respondents view the criteria for their jobs. Lastly, this study collected data concurrently using a cross-sectional approach.

Conclusion & Future Recommendation

Building information modelling, or BIM, has gained a lot of traction and is being used by numerous organisations and nations worldwide. Still, there is a significant disconnect between the enormous promise of BIM and its real application impact. This article highlights the theoretical and practical significance of BIM users and their happiness with BIM application and development, based on an analysis and compilation of available research. The factors influencing BIM user happiness were examined and confirmed using the structural equation model, presuming that BIM users and BIM user satisfaction are defined. It is noted that significant elements influencing BIM user satisfaction in building projects include perceived utility, perceived simplicity of use, system quality, information quality, and service quality. Future research can investigate the impact of some additional variables to explore BIM user satisfaction in a deeper manner. Secondly, this article takes individuals as the research object and only considers individual satisfaction. However, the satisfaction of enterprises as large users of BIM technology is indeed unknown. Therefore, future research can explore BIM satisfaction from an organizational perspective. This study analyzes satisfaction during BIM use, but satisfaction changes over time. Therefore, changes in satisfaction can also be analyzed from the time dimension, such as changes in satisfaction before and after BIM implementation.

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