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Research on the Current Situation and Improvement Strategies of BIM Learning in Vocational Colleges

Yun Zhou[1*], Md Gapar Md Johar[2]
[1]Zhe Jiang College of Construction, Hangzhou, China; Post Graduate Center, Management and Science University, Malaysia
[2]Software Engineering and Digital Innovation Center, Management and Science University, Malaysia
* Corresponding author: Yun Zhou, 321012021070032@pgc.msu.edu.my

Abstract—*This paper focuses on the current situation of Building Information Modeling (BIM) learning in vocational colleges. BIM technology holds great significance in the Architecture, Engineering & Construction (AEC) industry, yet there are several issues in vocational college BIM education. Students often lack awareness of the value of BIM learning, and confidence in learning it. Moreover, the outdated facilities in some vocational colleges fail to meet students' learning needs, and many teachers are unable to provide sufficient support due to late start of BIM talent cultivation and lack of practical experience. To address these problems, policymakers should introduce relevant policies to enhance students' awareness, boost their confidence, optimize educational facilities, and facilitate teachers' ability improvement. Higher education institutions need to establish a comprehensive curriculum system, optimize teaching, improve facilities, and enhance teachers' capabilities. Teachers should guide students to recognize BIM's value, strengthen their confidence, achieve effective teaching despite facility limitations, and better support students' learning. These measures aim to promote students' effective learning and application of BIM technology and drive the in-depth development of BIM education.*

Keywords— *Building Information Modeling (BIM); Vocational Colleges; BIM Learning; Current Situation; Improvement Strategies.*

I. INTRODUCTION

Building Information Modeling, known as BIM, is a form of digital technology development in the Architecture, Engineering & Construction (AEC) industry. BIM is a technology that has the ability to replicate the physical and functional properties in a three-dimensional format, incorporating building information that serves as the foundation for decision-making throughout a building's lifecycle, from conception to destruction (Parung et al., 2019). Implementing BIM in the construction sector can produce design needs saving about 50%, a reduction in construction human resource needs by 26.66% and operational needs saving approximately 52.25% (Ramadhan et al., 2022).

Indeed, the construction industry is showing an increasing interest in BIM, and the gradual acceptance of BIM is creating job opportunities for students proficient in this methodology's BIM technology (Bosch-Sijtsema et al., 2019; Charef et al., 2018). The construction industry is experiencing a significant surge in demand for technically skilled professionals with expertise in BIM, with a talent gap of 130,000 in 2023. These individuals must not only possess software expertise but also demonstrate interdisciplinary collaboration skillsills (Shojaei & Burgess,2023).

Despite significant advancements in BIM education research, several notable deficiencies still persist. i） The majority of studies concentrate on BIM education at undergraduate and postgraduate levels, with a relatively limited number of studies exploring BIM education within vocational colleges. Nonetheless, the escalating demand for technically proficient professionals skilled in BIM within the construction sector underscores the growing significance of vocational education. ii）While existing research He has evaluated the effectiveness of different teaching methods; however, studies focusing on student factors remain scarce.

II. THE CURRENT STATE OF BIM LEARNING

BIM has emerged as a revolutionary technology in the AEC industries, promising to transform traditional design and construction processes (Yilmaz, 2023). With its ability to enable seamless collaboration, enhance project efficiency, and drive sustainability, BIM has become an essential tool for professionals in the AEC sector. As the demand for BIM expertise continues to grow, vocational colleges are increasingly incorporating BIM into their curricula to equip students with the necessary skills and knowledge. However, despite its potential, the adoption of BIM in education faces several challenges. This section will delve into the current state of BIM learning, examining the various issues that students encounter in their efforts to master this innovative technology.

A. *Students lacked awareness of the value of BIM learning*

In the prevailing educational and professional landscapes, BIM has emerged as an innovative and transformative technology, endowing it with substantial potential to instigate a revolutionary change within the AEC sectors. The value proposition of BIM transcends its mere technical facets. It not only facilitates more meticulous architectural designs and efficient collision detection but also engenders seamless collaboration among diverse stakeholders involved in a project. (Mollasalehi,2022) This collaborative edge significantly bolsters the overall quality and operational efficiency of design and construction processes. Moreover, BIM assumes a pivotal role in propelling the sustainability agenda within the AEC industry. Through its capacity to accurately simulate energy consumption patterns and environmental impacts, BIM empowers stakeholders to make more informed decisions, thereby enabling enhanced resource management and a reduction in environmental footprints. In the long-term perspective, proficiency in BIM can unlock a multitude of career prospects within an increasingly digitalized job market.

However, a formidable impediment persists: students exhibit a conspicuous deficiency in recognizing the intrinsic value of BIM learning. A primary contributing factor to this deficit is the limited exposure that students encounter regarding the practical applications and benefits of BIM throughout their academic tenure. A significant number of vocational colleges continue to predominantly adhere to conventional teaching methodologies and curricula, which place a greater emphasis on traditional design and construction techniques. Consequently, students are frequently deprived of opportunities to comprehensively grasp how BIM can streamline their prospective work processes, augment their competitiveness in the job market, and contribute to the sustainable advancement of the industry.

Another underlying cause for this lack of awareness is the inadequate communication and promotion efforts within educational institutions. Faculty members, often encumbered by onerous teaching responsibilities and research obligations, may lack the requisite time and resources to effectively convey the value of BIM to students. They might prioritize the imparting of fundamental knowledge and skills essential for examinations over delving into the practical significance of BIM in real-world contexts.

Furthermore, the industry itself bears a share of the responsibility for this situation. There is a dearth of concerted efforts from the AEC industry to promote BIM among students. Companies may be predominantly focused on their immediate interests and project requirements, thereby failing to actively engage with educational institutions to showcase the value of BIM in a manner that resonates with students. This lack of industry-academia collaboration exacerbates students' limited understanding of BIM's potential.

Additionally, in vocational colleges, approximately 60% of high-performing students are occupied with preparations for the higher education entrance examination. As a result, they tend to marginalize the study of non-examinatory subjects, including BIM. In some instances, they may even entirely eschew professional practice and training related to BIM. This not only diminishes the emphasis on both theoretical education and practical skill development within relevant fields but also severely impedes the cultivation of students' overall professional competencies. Given that BIM learning is not incorporated into the subjects of the higher education entrance examination, some students lack the requisite motivation to explore its value, potentially causing them to miss out on valuable career development opportunities within the AEC industry (Peng et al., 2022; Ao, 2024).

B. Students Exhibited Low Confidence to learn BIM

A substantial number of students demonstrate a marked deficiency in confidence when undertaking the learning of Building Information Modeling (BIM). This sense of apprehension can be ascribed to a convergence of multiple factors, each of which contributes significantly to the erosion of their self-assurance within this particular domain.

The intricate and sophisticated nature of BIM software, characterized by its extensive repertoire of tools and functions, frequently serves as a formidable impediment. The overwhelming complexity of the software creates a psychological barrier that is arduous to surmount. As a relatively novel technology integrated into academic curricula, the novelty of BIM presents its own distinct set of challenges. Students generally have limited exposure to analogous digital design and management systems. This dearth of familiarity gives rise to feelings of unease and discomfort, as they are thrust into an unfamiliar technological realm without the requisite prior experience to establish a sense of stability and confidence.

The interdisciplinary requisites of BIM exacerbate the situation. Proficiency in BIM necessitates a comprehensive and in-depth understanding of architectural, engineering, and construction principles concurrently. This demand for a broad and profound knowledge base can be particularly daunting, especially for students who are already grappling with the rigors of their respective academic disciplines. Consequently, it often intensifies their feelings of self-doubt, leading them to question their capacity to meet these exacting standards.

Another factor contributing to students' lack of confidence is the variation in their levels of computer self-efficacy. Students with lower computer self-efficacy tend to perceive the technical aspects of BIM as significantly more challenging. They are less inclined to attempt complex tasks or explore the advanced features of the software, driven by a fear of failure. This self-limiting behavior not only impedes their learning progression but also reinforces their negative self-perception regarding their ability to master BIM.

Moreover, the absence of an adequate support infrastructure further deteriorates the situation. In the absence of tailored instructional guidance that can address individual learning requirements, students may find themselves struggling to make sense of the intricate concepts and software operations inherent in BIM. The lack of opportunities for peer collaboration also deprives them of the benefits associated with shared learning experiences, such as mutual support, knowledge exchange, and the motivational boost derived from working collectively towards a common objective. Additionally, the scarcity of real-world case studies that illustrate the practical applications of BIM leaves students without a clear comprehension of how the technology is implemented in actual projects, thereby further undermining their confidence.

The deficiency of confidence in BIM technology not only hinders individual learning but also poses a substantial obstacle to its widespread adoption across academic and professional spheres within the architecture, engineering, and construction industries.

C. Facilities were Unable to Meet the Needs of Students

In vocational colleges, the computer configurations at present generally manage to meet the basic requirements during the teaching of courses like Basic Computer Skills, Computer-Aided Design (CAD), Measurement and Pricing. These courses typically demand relatively modest computing power, and the existing setups can cope with them to a certain extent. However, when it comes to the advanced applications of BIM, such as BIM modeling and the practical application of BIM models, the situation takes a sharp turn for the worse. The majority of computers in vocational colleges are woefully inadequate in terms of the necessary configurations required to run BIM software effectively.

The complexity and resource-intensive nature of BIM software necessitate a high level of computing performance. Unfortunately, the current computer systems in these institutions often lack the processing power, memory capacity, and graphics capabilities needed to handle BIM tasks smoothly. Moreover, the market is teeming with a vast and diverse range of modeling and model application software related to BIM. Due to financial limitations and the impracticality of procuring every single software package, vocational colleges find it extremely difficult to obtain a comprehensive suite of relevant software. Currently, only the mainstream software and plugins with well-established cooperative relationships are installed. This selective installation means that students have limited access to the full spectrum of tools available in the BIM field, which significantly restricts their learning experience and development. As a result, there is a profound mismatch between the software and hardware resources provided by the colleges and the educational models and long-term career development goals of professional students.

BIM technology is a highly comprehensive and sophisticated discipline. Owing to the diverse application stages, including the design, construction, and operation phases, as well as the wide variety of service scenarios and distinct display effects, students who aim to master professional BIM software are required to acquire proficiency in multiple aspects. This encompasses not only various modeling techniques but also animation production and even video editing software. In addition, for students in the interdisciplinary fields that intersect architecture with other majors, they need to delve deeper into specialized modeling and application software, which further complicates their learning journey.

To ensure the optimal performance of BIM software, specific and relatively stringent software and hardware configurations are essential. A 64-bit Windows 10 operating system serves as the foundation, complemented by a multi-core 64-bit Intel or AMD processor with a minimum clock speed of 2.5 GHz. At least 16 GB of Random Access Memory (RAM) is required, with 32 GB or more being highly recommended to handle complex BIM projects efficiently. A graphics card supporting DirectX 11 and equipped with at least 4 GB of video memory is necessary for rendering high-quality graphics, while Solid State Drive (SSD) storage ensures fast data access and transfer, and a stable network connection is crucial for collaborative work and accessing online resources. Regrettably, the computer setups in most vocational schools fall far short of these requirements, failing to effectively meet the flexible learning needs of students for BIM. To address this pressing issue and accommodate students' learning demands during extracurricular and fragmented time periods, vocational colleges must make substantial efforts to enhance their informatization levels and undertake thorough upgrades of their computer software and hardware infrastructure. Only in this way can students be provided with a more conducive learning environment for BIM technology.

D. Insufficiency of Teachers in Supporting Students' Learning Endeavors

In developing countries, the cultivation of Building Information Modeling (BIM) talents has a relatively late start. Presently, a significant majority of college instructors who are responsible for delivering BIM education did not have the opportunity to be exposed to this technology during their own academic pursuits. Instead, they had to acquire the relevant knowledge through subsequent regular training programs in order to meet the teaching requirements.

This situation has given rise to a limited understanding of BIM among educators within academic institutions. BIM is a technology with a strong practical orientation, which demands hands-on experience in specific projects to fully comprehend its application processes and appreciate its true value. However, many university instructors frequently move between different educational institutions. Due to this mobility, they often lack in-depth insights into the persistent issues and challenges that are inherent in traditional project management. Consequently, when it comes to implementing and adopting the new BIM technology in their teaching, they face difficulties in seamlessly integrating theoretical knowledge with practical applications. This inability to effectively blend theory and practice has led to suboptimal outcomes in the development of BIM talents, failing to fully equip students with the necessary skills and knowledge for real-world scenarios.

In vocational colleges, bringing in industry experts is a vital strategy for building a robust teaching faculty. Nevertheless, the recruitment of industry teachers in the domain of BIM presents substantial challenges. On one hand, there is a severe shortage of BIM professionals in the industry. Those individuals who meet the technical standards set by universities are not only scarce but also in high demand across various sectors. This scarcity makes it extremely difficult for vocational colleges to attract and hire experienced BIM experts as teachers. On the other hand, as an emerging technology in the construction sector, BIM is mainly embraced by younger practitioners. These professionals, although proficient in using BIM technology, often lack the educational qualifications and professional titles that universities typically require. Universities usually have strict criteria regarding the academic backgrounds and professional achievements of their teaching staff. As a result, even though there may be many talented BIM practitioners in the industry, only a small number of them can meet the stringent requirements of vocational colleges.

Moreover, the gap between industry practices and academic teaching methodologies also poses a problem.

Industry experts may find it challenging to adapt their practical knowledge and skills into an effective teaching format that can be easily understood by students. They may struggle with structuring their lessons, using appropriate teaching methods, and evaluating students' learning progress. This further complicates the process of integrating industry expertise into the academic environment of vocational colleges.

The current situation regarding teachers' ability to support students' BIM learning efforts in vocational colleges is far from ideal. Addressing these issues requires a comprehensive approach, including improving the training of existing instructors, reevaluating the recruitment criteria for industry teachers, and bridging the gap between industry practices and academic teaching to better prepare students for successful careers in the BIM field.

III. Improvement Strategies

In the current context where Building Information Modeling (BIM) technology is increasingly becoming the core competitiveness of the Architecture, Engineering, and Construction (AEC) industry, students, as the main force of the future industry, their level of learning and mastery of BIM technology is of vital importance. However, currently, there are numerous issues such as students' insufficient awareness of the value of BIM learning, a lack of confidence in their learning, the outdated facilities in vocational colleges that are unable to meet the learning needs, and the limited supporting capabilities of teachers. These problems severely restrict students' effective learning and application of BIM technology.

In order to effectively enhance students' learning outcomes of BIM and promote the in-depth development of BIM technology in the field of education, it is necessary for policymakers, higher education institutions, and teachers to collaborate synergistically. Each party should play a crucial role and adopt targeted and effective measures to address these issues. The following are the specific improvement strategies proposed from these three aspects.

A. *Improvement Strategies for Policymakers*

In the current context where Building Information Modeling (BIM) technology is playing an increasingly crucial role, policymakers shoulder the key responsibility in promoting educational development and enhancing students' mastery and application capabilities of BIM technology. In response to issues such as students' lack of awareness of the value of BIM learning, insufficient confidence in learning BIM, outdated facilities in vocational colleges, and limited support capabilities of teachers, policymakers can take the following measures:

a) Enhancing Students' Awareness of the Value of BIM Learning

Policymakers should actively introduce policies to facilitate in-depth cooperation between universities and enterprises in the construction industry. By establishing platforms for students to participate in BIM technology practical projects and internships, students can truly experience the value of BIM learning through hands-on operations. Meanwhile, special publicity funds should be set up to encourage the media to carry out comprehensive and multi-faceted popular science and publicity activities regarding BIM technology and its value. This will create a favorable atmosphere in society that attaches importance to BIM learning, guiding students to establish correct learning concepts and recognize the significance of BIM technology in their future career development.

b) Boosting Students' Confidence in Learning BIM

Policies should be formulated to require universities to incorporate computer basic skills training into the compulsory courses of talent cultivation programs and provide corresponding credit recognition. This will comprehensively improve students' computer operation skills and lay a solid foundation for BIM learning. In addition, special funds should be allocated for research projects on cultivating students' self-confidence. Universities should be encouraged to conduct in-depth educational research in this regard, explore effective models and methods for cultivating self-confidence, and widely promote them in practice. This will help students overcome their fear of BIM learning and enhance their confidence in this area.

c) Optimizing the Allocation of Educational Facilities Resources in Vocational Colleges

Increase the investment in educational funds for vocational colleges, and clearly stipulate that a certain proportion of the funds should be used for updating hardware facilities and developing online educational resources to meet students' flexible and practical learning needs. At the same time, formulate industry standards and specifications for the construction and updating of educational facilities in vocational colleges. Require vocational colleges to regularly evaluate and upgrade their facilities and equipment to ensure that they are in line with the development needs of the industry, thus providing students with good learning conditions.

d) Facilitating Teachers' Ability to Support Students' BIM Learning

Introduce incentive policies to support teachers in participating in domestic and international academic conferences, training courses, and professional certification exams related to BIM technology, and provide rewards to teachers who achieve excellent results. Establish a special fund for teachers' teaching research, encouraging teachers to carry out research on innovative teaching methods and curriculum design based on BIM teaching. This will continuously improve the quality of teaching and enable teachers to better support students' learning efforts.

B. *Improvement Strategies for Higher Education Institutions*

As an important front for cultivating BIM professionals, higher education institutions should actively adopt effective measures to address various issues that students encounter during the BIM learning process, and improve students' learning outcomes and comprehensive qualities.

a) Promoting Students' Recognition of the Value of BIM Learning

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Higher education institutions should establish a systematic and comprehensive BIM-related curriculum system. In addition to setting up specialized courses, general courses regarding the development trends of BIM technology in the industry and career prospects should also be added. Invite senior industry experts to teach these courses to broaden students' horizons. Meanwhile, organize students to participate in BIM technology application competitions and academic lectures, and regularly arrange for students to visit well-known construction projects that utilize BIM technology. This enables students to personally experience the charm and value of BIM technology, stimulating their interest and enthusiasm for learning.

b) Drivening BIM Confidence Enhancement

Optimize the teaching of basic computer courses. Implement stratified teaching according to students' computer proficiency levels, and provide personalized tutoring for students with a weak foundation. Gradually improve students' computer operation skills and self-confidence. Establish a BIM learning support center, equipped with professional instructors and advanced learning facilities. Provide students with comprehensive learning consultations, technical support, and practical guidance to help them overcome learning difficulties and enhance their confidence in learning.

c) Optimizing Educational Facilities to Meet Students' Learning Needs

Higher education institutions should rationally plan educational resources, reduce investment in traditional low-efficiency hardware facilities, and increase the procurement and construction of digital teaching resources such as online learning platforms and virtual simulation software. Establish long-term and stable cooperative relationships with software vendors and hardware manufacturers, keep abreast of the latest technological trends in the industry in a timely manner, update and upgrade teaching facilities and equipment. Ensure that they can meet students' flexible and practical learning needs, and provide students with a high-quality learning environment.

d) Enhancing Teachers' Ability to Support Students' BIM Learning

Establish a regular teacher training mechanism. Organize teachers to participate in BIM technology training and teaching method seminars on a regular basis. Invite industry experts and educational technology experts to give lectures and provide guidance to improve teachers' professional qualities and teaching abilities. Set up a teacher teaching innovation reward system. Reward and commend teachers who adopt novel teaching methods and achieve remarkable teaching results in BIM teaching. Encourage teachers to continuously explore and innovate, improve teaching quality, and better support students' learning.

C. Improvement Strategies for Teachers

Teachers play a crucial guiding and supporting role in students' BIM learning process. In the face of the problems that students encounter during their studies, teachers should actively take effective measures to enhance the quality of teaching and meet students' learning needs.

a) Guiding Students to Recognize the Value of BIM Learning

During the teaching process, teachers should introduce a diverse range of practical cases and elaborate in detail on the applications and advantages of BIM technology throughout the entire project life cycle. By doing so, they can guide students to think deeply about the significance of BIM learning for their future career development. Teachers should also encourage students to participate in research projects and group practical activities, enabling students to personally experience the value of BIM technology while solving practical problems. This helps to cultivate students' profound interest and enthusiasm for BIM learning.

b) Strengthening Students' Confidence in Learning BIM

For students with low computer self-efficacy, teachers should adopt a step-by-step teaching approach, starting from basic operations. They should provide more patient guidance and positive feedback to gradually boost students' confidence in learning. Teachers can organize students to engage in group cooperative learning, guiding students to communicate and assist each other. By fully leveraging the exemplary and motivating effects of their peers, students can jointly enhance their confidence and capabilities in learning.

c) Achieving Effective Teaching in Response to Inadequate Facilities

Teachers should make full use of existing facilities and online teaching resources, and meticulously design a variety of teaching activities, such as online-offline blended teaching and virtual simulation experiments, to compensate for the limitations of teaching caused by insufficient facilities. At the same time, teachers should guide students to make rational use of network resources for autonomous learning, recommend high-quality online courses and learning platforms, and cultivate students' autonomous learning ability and information literacy. This ensures that the teaching effect is not affected by the facility conditions.

d) Enhancing the Ability to Support Students' BIM Learning

Teachers should take the initiative to pay attention to the latest development trends of BIM technology and industry application cases, constantly update their knowledge systems, and integrate the latest technologies and concepts into their teaching. They should have an in-depth understanding of students' learning needs and individual differences, formulate personalized teaching plans according to students' characteristics, and provide targeted learning guidance and support. By meeting students' personalized learning needs, teachers can better support students' learning efforts and promote their all-round development.

IV. Conclusion

In conclusion, the research on the current situation and improvement strategies of BIM learning in vocational colleges reveals a complex yet promising landscape. BIM technology has emerged as a transformative force in the AEC industry, offering substantial benefits such as enhanced design precision, improved collaboration, and sustainable development. However, the implementation of BIM education in vocational colleges faces several challenges that hinder students' effective learning and application of this crucial technology.

Students' lack of awareness of the value of BIM learning, low confidence in their ability to master it, the inadequacy of outdated facilities, and the limited support from teachers are the major issues identified in this study. These problems are interconnected and have a cumulative impact on students' educational experience and future career prospects in the AEC industry.

To address these challenges, a multi-faceted approach involving policymakers, higher education institutions, and teachers is essential. Policymakers can play a pivotal role by introducing relevant policies to enhance students' awareness, boost their confidence, optimize educational facilities, and facilitate teachers' professional development. By promoting industry-university cooperation and publicizing the value of BIM, policymakers can create a favorable environment for BIM education.

Higher education institutions need to take proactive measures to establish a comprehensive curriculum system, optimize teaching methods, upgrade educational facilities, and enhance teachers' capabilities. By providing students with a well-rounded learning experience and equipping them with the necessary skills and knowledge, higher education institutions can better prepare students for the demands of the industry.

Teachers, as the frontline educators, have a crucial responsibility to guide students in recognizing the value of BIM learning, strengthening their confidence, and achieving effective teaching despite the limitations of facilities. By leveraging practical cases, adopting personalized teaching approaches, and integrating the latest industry trends into their teaching, teachers can inspire students' interest and enthusiasm for BIM and support their all-round development.

In the long run, the successful implementation of these improvement strategies will not only enable students to acquire the necessary skills and knowledge in BIM but also contribute to the overall development of the AEC industry. As the industry continues to evolve and embrace digital transformation, the demand for BIM professionals will only increase. By addressing the current challenges in BIM education, vocational colleges can play a vital role in bridging the talent gap and providing the industry with a competent and skilled workforce.

It is important to note that the improvement of BIM education is an ongoing process that requires continuous evaluation and adjustment. Future research could focus on evaluating the effectiveness of the proposed improvement strategies, exploring innovative teaching methods and technologies, and further understanding the factors that influence students' learning and adoption of BIM. By doing so, we can ensure that BIM education in vocational colleges remains relevant and effective in meeting the needs of the industry and students in the dynamic digital era.

In summary, through the collaborative efforts of policymakers, higher education institutions, and teachers, it is possible to overcome the current challenges and promote the in-depth development of BIM education in vocational colleges, thereby fostering the growth and success of students in the AEC industry.

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