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The Evaluation Research on BIM Literacy among College Students

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Abstract **– The construction industry is facing the inevitable trend of digital transformation, in which BIM technology plays a pillar role, but the lack of relevant BIM technical personnel, especially college students with BIM literacy makes it difficult to meet the needs of society, which directly affects the digital process of the construction industry, this paper through the literature found that scholars have paid attention to the problems related to BIM education, but there is no evaluation of the BIM literacy and the evaluation of BIM literacy. Therefore, this paper starts with digital literacy, defines BIM literacy, and finally constructs the evaluation index of college students' BIM literacy through the "iceberg model", which provides an important reference for the evaluation of college students' BIM literacy. The index system consists of five secondary indicators of basic knowledge, data analysis, teamwork, BIM thinking, BIM awareness, and 14 three-level indicators, which can provide an important reference for evaluating college students' BIM literacy and accelerate the digital transformation of the construction industry.**

Keywords **– College Students, Construction Industry, Bim Literacy, BIM Literacy Evaluation.**

I. Research Background

In recent years, the construction industry is experiencing an unprecedented digital revolution, in the trend of digital transformation, BIM plays an important role, which is not only a kind of software, but also a kind of all-round digital building lifecycle management mode, which provides a strong support for the sustainable development of the construction industry.

BIM is seen by academics as the backbone of the digital revolution. However, the application rate of BIM has not reached the ideal state. According to the data of relevant survey reports, the BIM application penetration rate in China in 2020 is still less than 40%, and the BIM application penetration rate in China in 2023 is only 43%, the main reason for this result is the shortage of talents, that is, the staff's BIM literacy is not high, so we need to cultivate talents, and the fundamental solution to the problem of the lack of BIM talents lies in the conduct of the institution's BIM teaching reform. As the reserve army and future force of BIM technology, students are the hope of the application and development of BIM technology, only by improving the mastery of BIM-related knowledge and application skills of college students, and cultivating BIM literacy among college students, can we promote the application and development of BIM technology and promote the digital revolution of the construction industry.

II. The Research Status at Home and Abroad

1. *BIM Concept and Development*

In 1974, Professor Chuck Eastman of Georgia University of Technology proposed the "Building Description System", namely the building information storage system, a computer system for storing and managing design, construction, and analysis information, due to the excessive cost of architectural drawings. This was the idea of BIM information integration, which was intended as a replacement for drawings, a concept that was ignored

because computers were too expensive at the time. In 1992, Van Nederveen and Tolman proposed "Building Information Mode", that is, building information model. They believe that participants in construction projects have different needs for building data and building information modeling helps to form a building model structure that meets these needs. This reflects the data sharing and synergy of BIM and also refers to modeling, which is hard proof that the BIM concept first emerged. In 2002, Autodesk published the BIM White Paper, which defined BIM as "Building Information Mode", that is, building information model. BIM modeling is the construction industry information technology application strategy, which marks the BIM research into the white-hot stage. In 2007, the first edition of the National BIM Standard in the United States defined BIM: BIM is the digital expression of the physical and functional characteristics of a facility; BIM is a shared knowledge resource, a process of sharing information about the facility to provide a reliable basis for all decisions throughout the life cycle of the facility, from concept to demolition; At different stages of the project, different stakeholders support and reflect their respective responsibilities by inserting, extracting, updating and modifying information in BIM. With the emergence of the first version of the BIM standard, the development of BIM has entered an era of great explosion. In 2017, the Ministry of Housing and Urban-Rural Development of China accurately defined BIM, which refers to the digital expression of its physical and functional characteristics as well as the design, construction, and operation in turn within the whole life cycle of a building. Based on the complete BIM model, all the data and information of the building entity at all stages of the building life cycle and its construction and use process can be described. Participants can query, utilize, update, and improve the BIM model information at any time to improve the level of project management and decision-making. It also brings new ideas and methods to solve the problems of "information island" and "information fault" in the whole life of buildings.

2. *BIM Education Related Research*

Although BIM technology is being promoted, there are many challenges in the development of BIM education, and BIM technology is not really integrated into the classroom. Most scholars have found that there are still some challenges in integrating BIM into higher education after research in colleges and universities, and have conducted questionnaires and face-to-face surveys on BIM education, and found that only 40% of the respondents really pay attention to the construction of BIM courses. Some scholars have also researched on Chinese universities and found that schools do not pay much attention to the construction of BIM courses and have low motivation to offer courses, mostly for a single course, which makes it difficult for students to build up a macroscopic understanding of the whole professional knowledge and ability system. Although more and more colleges and universities have opened BIM courses, due to the lack of BIM teaching system and experience, most of them are just basic and single teaching, letting students simply understand the principles of BIM technology. And most scholars believe that BIM education has significantly lagged behind the progress of the construction field, colleges and universities only teach BIM as a three-dimensional modelling tool, ignoring its practicality, which makes it difficult for students to connect the theoretical knowledge with engineering reality. Insufficient teacher ability, single education path, insufficient hardware facilities and resources are the reasons for the backwardness of BIM education, as well as the poor quality of BIM education classroom, scarce education resources, lack of systematic and professionalism, etc.

Therefore, many scholars have put forward suggestions on the curriculum teaching reform of BIM. Most sch-

-olars point out that the BIM curriculum reform should be carried out from both theory and practice, specifically from improving the BIM curriculum system, innovative teaching methods, enhancing teachers' strength, establishing practice bases, setting up practical training platforms, etc. Some scholars directly constructed teaching platforms to combine classroom practice with job requirements, so as to mobilise students' independent learning ability and improve their BIM literacy. Some scholars have directly constructed a teaching platform, innovative reform of the assessment mechanism, combined with job requirements for classroom practice, so as to mobilise students' independent learning ability and improve students' BIM literacy. Some scholars also focus on the BIM curriculum system, that should be adjusted to the curriculum and teaching content, innovative teaching methods and teaching resources, the establishment of a scientific and perfect evaluation system and other content. And on the basis of actual research, they put forward measures to improve the quality of the curriculum, integrate teaching resources, build a new type of nurturing platform, etc., and put these measures into practice to achieve good results.

III. Research Evaluation

In general, BIM-related technologies and applications have been developed and matured. Scholars have also turned their attention to the relevant research of BIM education and put forward profound and comprehensive insights into the current assessment and improvement of BIM education. The research points out that there are still some challenges in BIM education, which lags behind the development of BIM. Especially for the disconnection between BIM education and practice, and the deficiency of students' comprehensive quality training, this paper puts forward important reform suggestions. These suggestions not only focus on the combination of theory and practice but also focus on the construction of teaching platforms, the reform of assessment mechanisms, and the improvement of curriculum quality. These studies aim to improve the BIM literacy of college students, encourage and guide colleges and universities to conduct BIM literacy training for college students, improve the quality of BIM education, provide a valuable reference for the future development of BIM education, and also point out the direction for this paper to study the BIM literacy evaluation system of college students.

IV. Theoretical Model of BIM Literacy Evaluation of College Students

1. *BIM Literacy Definition*

At present, scholars at home and abroad do not clearly give the concept of BIM literacy, but put forward the concept of digital literacy which is similar to it. Some scholars point out that digital literacy is similar to cultural literacy, both of which require people to master the basic cultural knowledge and skills needed in social life and occupational positions. Some scholars have also studied the constituent elements of college students' literacy, and they believe that digital literacy is a requirement in the era of networking, and is the ability of individuals to solve problems by using computers and network tools.

The connotation of BIM literacy is part of the concept of BIM, which covers a lot of content, and the connotation of BIM literacy given by various scholars varies. Some point out that BIM literacy mainly includes four qualities, i.e., professional ability, practical ability, communication ability, and professional competitivene--ss. Some scholars also divide BIM literacy into four aspects, but the content is different, that BIM literacy includes professional ethics, health quality, teamwork, communication and coordination. Some scholars have

carried out deeper research, pointing out that BIM literacy not only includes practical ability, teamwork ability, but also includes adaptability, innovation, and sense of responsibility.

As a result, this paper considers BIM literacy as a requirement under the digitalization process of construction companies and the ability of an individual to be able to utilize BIM-related applications, and relevant tools for construction engineering issues, including proficiency in the use of BIM tools and processes as well as understanding and ability to manage and collaborate on BIM projects.

2. *A Framework of BIM Literacy Evaluation A. Theoretical Basis*

The "competency model", also known as the "iceberg model", was put forward by Harvard University professor McLellan in 1973. The theory divides human personal qualities into two parts, including explicit and implicit qualities, of which explicit qualities belong to the "upper part of the iceberg model", while implicit qualities are hidden in the "lower part of the iceberg model". The "upper part of the iceberg model" covers basic knowledge and skills, which are part of the external manifestation and relatively easy to measure. This part is usually changed and grown through training and education. However, the "lower part of the iceberg model" includes hidden literacy such as social role self-image perceptions, traits, and motivation, which constitutes the foundation that lies deep beneath the surface. This part of literacy is not easy to be influenced by the outside world and is difficult to assess quantitatively, but it plays a crucial role in people's behavior and performance. The competency model provides a generic, structured framework for analyzing qualities and is widely used in the assessment and development of professional qualities. The model reveals that knowledge and skills at the top of the iceberg are just the tip of the iceberg, and that self-image, personality qualities, and motivation buried underneath the iceberg are important predictors of an individual's future performance. Through this model, HR managers can better understand the overall quality of an individual and provide them with targeted training and development programs.

B. *Evaluation Model*

BIM literacy of college students also belongs to the category of literacy, which also has the characteristics of general quality. Therefore, the "iceberg model" mentioned above is introduced to this study, which defines the constituent elements of the quality model: ① knowledge, which refers to the factual or empirical information that an individual possesses in a specific field; ② skill, which refers to the ability of an individual to effectively use knowledge to complete a specific job; ③ social role, which means that the image, temperament and style that an individual displays in public; ④ Self-image, refers to the individual's ability to perceive his/her own state, including his/her own strengths and weaknesses, thinking mode, problem-solving style, characteristics of interaction with others, and the reasonable positioning of his/her own role, etc.; ⑤ Quality, including temperament, personality, and interest is a consistent response to the performance of the individual, such as introversion and extroversion, and different temperament types; ⑥ Motivation, the internal drive that pushes an individual to take a series of actions in order to achieve a certain goal, e.g., a person with a strong achievement motivation will consistently set goals for themselves and strive to achieve them.

Based on this model, and combined with the relevant literature, this paper concludes that among the "explicit literacy" of college students' BIM literacy, knowledge, skills, and social roles mainly correspond to basic knowledge and teamwork, i.e., whether college students have basic BIM knowledge and skills, whether they can

successfully collaborate and communicate with each other in a team, and the degree of adaptability. In terms of "implicit literacy", self-image corresponds to the BIM thinking of college students, including problem identifi--cation, problem-solving, and decision-making ability; quality and motivation correspond to the BIM awareness of college students, including willingness to learn and innovative thinking; the formation of BIM thinking and awareness has a fundamental impact on the overall enhancement of BIM literacy.

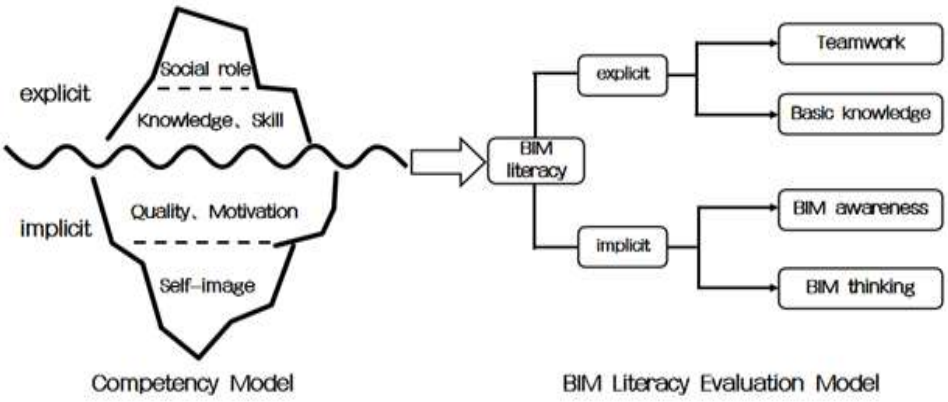

Fig. 1. BIM literacy evaluation model of college student.

V. BIM Literacy Evaluation Index System of College Students

1. *Review of Research*

This paper focuses on the study of digital literacy assessment frameworks to provide a basis for establishing a BIM literacy assessment framework.

The digital literacy framework was first proposed by Israeli scholar Eshet-Alkalai in 2004, which included five components such as picture-visual literacy, re-creative literacy, and branching literacy. Paul Gilster then proposed ten more specific elements that constitute digital literacy competencies, including the ability to judge information, the ability to read in hypertext environments, knowledge assembly skills, and so on, involving digital skills, dialectical thinking, social communication, and many others. With the increasing attention to digital literacy, some authoritative organizations have released digital literacy frameworks, among which the typical ones are: the Digital Literacy Framework for European Citizens 1.0 released by the European Union in 2013, which specifically includes the communication domain, the content creation domain, the information domain, the security domain, the problem-solving domain, as well as 21 sub-divisions of literacy. In 2018, UNESCO designed the Global Framework for Digital Literacy based on various authoritative digital literacy frameworks, combined with empirical research, which includes seven literacy dimensions and 26 specific indicators.

China's digital framework research is mainly on foreign frameworks, Ma Xing et al. proposed a digital literacy framework for college students based on the EU digital literacy framework, which consists of three dimensions: digital communication ability, digital innovation ability, and digital critical ability. Wang Shuping et al. constructed a digital literacy framework for college students from the actual situation of China's colleges and universities, combining China's national conditions, which consists of seven dimensions, including the ability to correctly perceive data and information, the ability to communicate and exchange data, and digital character and values.

Overall, the Digital Literacy Framework for European Citizens 1.0 and the Global Framework for Digital Literacy are the two most successful frameworks, both of which focus on problem-solving, data analysis, etc., in addition to communication skills, creativity, and collaboration skills, which are also important components of each framework.

2. *BIM Literacy Evaluation System*

After comparing and analyzing the digital literacy frameworks of the European Union and the United Nations, "data analysis", which is a common concern of the two frameworks and is relevant to university students, has been incorporated into the secondary indicators of the frameworks. Data analysis literacy is a high-level literacy requirement in BIM literacy for university students. To promote the continuous development of BIM technology, university students must be able to analyze and secure all kinds of data in the process of BIM, explore and innovate BIM solutions, and try to understand all kinds of new data encountered in the course of their work, on the premise that they are proficient in the existing BIM technology..

According to the above analysis, the BIM literacy framework for university students constructed in this study consists of five secondary indicators:basic knowledge, data analysis, teamwork, BIM thinking, and BIM awareness..

After determining the secondary indicators, this paper uses subject terms, keywords, titles, abstracts, etc. to retrieve literature from China Knowledge, Wanfang Data Knowledge Service Platform, Cochran Library, Web of Science, and other domestic and international databases, design the outline of the conference with college students' BIM literacy as the main body, invite college teachers as well as enterprise experts to conduct brainstorming meetings and organize and refine the content of the conference. The content of the meeting was collated and refined, combined with the theory of competency model, and the feasibility of indicators was considered from the obvious and hidden aspects, and 14 three-level indicators were summarised, obtaining the framework of college students' BIM literacy as shown in Table 1 below.

Table 1. BIM literacy evalution index system of college students.

	Secondary Indicator	**Three-Level Indicator**	**Three-Level Indicator Content Definition**
BIM literacy of college students	Basic knowledge (BK)	BIM basic theoretical knowledge (BK1)	Understand basic BIM concepts and be familiar with the operation of BIM software
		BIM modeling and analysis (BK2)	Able to create and edit BIM models, with certain application skills
		Adaptation (BK3)	Able to adapt to different BIM project requirements and work environments
	Data analysis (DA)	Data collection capability (DA1)	Collect and integrate BIM data in a targeted and planned way
		Data integration and analysis ability (DA2)	Integrate the data generated in the process of project implementation and tap its value
		protect equipment (DA3)	Protect your device and know how to download legitimate BIM software
		protect data (DA4)	Learn about personal and team data protection measures

	Secondary Indicator	Three-Level Indicator	Three-Level Indicator Content Definition
	Teamwork (TW)	Data comprehension ability (TW1)	Be able to understand the meaning of the data in the theoretical BIM software
		Team communication ability (TW2)	Able to clearly express the needs and ideas of the BIM project
		Ability to work across teams (TW3)	Able to collaborate with team members of different disciplines to complete BIM projects
	BIM thinking (BT)	Problem identification ability (BT1)	Be able to quickly find and solve problems and hidden dangers in BIM projects
		decision-making ability (BT2)	Ability to make balanced decisions in BIM projects
	BIM awareness (BA)	BIM learning willingness (BA1)	Willingness to actively learn and use BIM technology Have the initiative to implement the integration of BIM technology and construction industry
		ability of creative thinking (BA2)	Provide innovative BIM solutions to improve project efficiency and quality

3. *Index Weight Determination*

In this paper, the index weight is determined by the analytic hierarchy process (AHP), which is a hierarchical weight decision analysis method. Its principle is to decompose complex problems into different factors and boil the factors into different levels. By comparing and judging the factors at each level, the overall ranking of the relative weights of the lowest level and the top-level evaluation factors is formed. In this analytic hierarchy method, 7 experts were hired to compare the evaluations of BIM literacy of college students, among which enterprise managers and 2 were college student managers. All the experts knew and were familiar with the psychology and life fields of college students. There are 5 judgment matrices in each questionnaire. According to the evaluation questionnaire of the experts, the consistency satisfaction value of the judgment matrix is calculated, and the result shows that the consistency satisfaction of the judgment matrix of each expert is less than 0.1, indicating good consistency According to the analytic hierarchy process (AHP), the weights of each layer of the evaluation indexes of BIM literacy of college students are calculated, as shown in Table 2.

Table 2. BIM litercay evaluation index system of college students.

First-Order Indicator	Absolute Weight	Secondary Indicator	Absolute Weight	Three-Level Indicator	Absolute Weight
BIM literacy of college students	1.000	BK	0.299	BK1	0.161
				BK2	0.066
				BK3	0.072
		DA	0.146	DA1	0.048
				DA2	0.05
				DA3	0.016
				DA4	0.032

First-Order Indicator	Absolute Weight	Secondary Indicator	Absolute Weight	Three-Level Indicator	Absolute Weight
		TW	0.156	TW1	0.05
				TW2	0.062
				TW3	0.044
		BT	0.230	BT1	0.124
				BT2	0.106
		BA	0.169	BA1	0.113
				BA2	0.056

VI. Conclusion

This paper establishes a comprehensive assessment index system for college students' BIM literacy. The index system consists of five secondary indicators of basic knowledge, data analysis, teamwork, BIM thinking, and BIM awareness, and 14 tertiary indicators of BIM learning willingness, BIM modeling and analysis skills, data comprehension, problem identification, innovative thinking ability, and so on.

1. This paper defines the concept of BIM literacy. This paper defines the relevant concepts of BIM literacy through the research related to digital literacy, which creates a new research direction and provides a theoretical basis for the subsequent establishment of a BIM literacy assessment index system.

2. The evaluation framework of BIM literacy is established. Based on the "competency model", this paper compares the implicit and explicit characteristics of college students with their attributes and forms a theoretical model of BIM literacy evaluation, which provides an important basis for evaluating college students' BIM literacy. In addition, the subsequent reform and optimization of BIM education can also draw on this indicator framework.

3. The indicators of the BIM literacy assessment index system were identified. In this paper, the indicators of the indicator system were screened according to existing research and literature analysis, and the weights of the indicators were calculated using the hierarchical analysis method, which can better study and assess the BIM literacy of college students, and provide a basis for subsequent research.

References

[1] EO intelligence.2022 China Construction Industry Digital Transformation Research Report [R]. 2022.
[2] Huang Li, Zhou Yubin, Jiang Xudong. Research on current situation and improvement strategy of BIM applied talents training [J]. Engineering Economy, 2021, 31(12) :44-46.
[3] An Outline of the Building Description System. Institute of Physical Planning. Carnegie-Mellon University, September 1974.
[4] Modelling multiple views on buildings. Automation in Construction, 1992, 1(3): 215–24.
[5] Burcin Becerik-Gerber;David J.Gerber;Kihong Ku.The pace of technological innovation in architecture,engineering,and construcion educaion:integraing recent trends into the curricula [J]. Journal of Information Technology in Construction, 2011, (16)24: 411-432.
[6] B. lawrence,Readying quantity surveyors to meet the UK government BIM mandate for 2016 and beyond ,BSc dissertation,University of Portsmouth
[7] Dang Bin. Research on BIM based Practical Teaching Reform of Engineering Management Major -- A case study of teaching reform of School of Urban and Rural Planning and Architectural Engineering of Shangluo University [J]. Real Estate World, 2022(22): 88-91.
[8] Deng Jingwen. Analysis of problems and countermeasures in classroom teaching of engineering cost major in higher vocational colleges [J]. Jiangxi Science,2020,38(02):290-292.
[9] Jia Hao, Zhao Ying, Huo Haixia et al. Research on reform and innovation of BIM Science and Practice integrated teaching of Hydraulic engineering based on "Internet+Higher Vocational Education"[J]. Science wind, 2023(36): 101-103.
[10] Yu Hui. College Students' basic literacy: Concepts, elements and their realization[J].Journal of Zunyi Normal University,2020(03).
[11] Liao Qian. Teaching reform and exploration of "Railway Engineering BIM Technology" course in the digital age [J]. Policy & Scientific Consult, 2023(09): 117-119.

[12] Xu Ying, Zhou Yin-Zhi, Zhong Jie et al. Research on BIM capability training model under the "group collaboration" model [J]. Education and Teaching Forum, 2021(28): 161-164.
[13] NOFHA RINA.Digital Literacy Education in the Industrial Revolution 4.0 In Alquran Primary School Students [EB/0L][2020-11-12].
[14] David Bawden. Information and digital literacies: a review of conceptsJl. Journalof Documentation, 2001, 57(2).
[15] Ma Xing, Feng Lei. The Value, goal and strategy of Digital literacy education for college students[J].Jiangsu Higher Education, 2021 (11): 118-124.
[16] Wang Shuping, Chen Haifeng. Cultivation of college students' digital literacy in the digital age: Value, connotation and path [J]. Journal of Southwest Minzu University (Humanities and Social Sciences Edition), 2021, 42(11): 215-220.

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