

Research and Assessment on BIM Engineering Management Project Based on Open Platform

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Abstract: The number of annual production of architecture of China is top in the world. Currently, the transform of construction is on urgent. According to the development and construction needs of the “Belt and Road”, and to achieve the goal of the transform for construction industry, it is necessary to carry out effective promotion of BIM and utilize practical projects to promote BIM technology. The BIM teaching in colleges and universities is still mainly based on the BIM theory explanation or the operation and modeling of BIM software, the whole-process application teaching of BIM in practice projects is not deep enough, there need some in-dept experience to perfect the research. This paper focus the utilization of an open platform called Trimble, based on a project called Dongjiageng Community Placement Room Project, using case analysis, fuzzy comprehensive evaluation and other methods, analyzing the key points and factors of how to choose the platform or perfect the management of BIM use in the life cycle of project, and evaluating the two platform's difference, summarizing the characteristics of different platforms and puts forward key points for attention to in future BIM teaching and practice.

Keywords: BIM, Open platform, Industry-university-research cooperation, Engineering management

1. Introduction

Construction industry is the pillar industry of China's national economy, the number of annual production of architecture of China is top in the world. Some information of construction industry can be seen in Figure1. But comparing with other industries, the low production efficiency is extremely undeserved. The main reason is that the mode of traditional management in construction industry has big disadvantages. Currently, the transform of construction is on urgent because of the high urbanization rate.

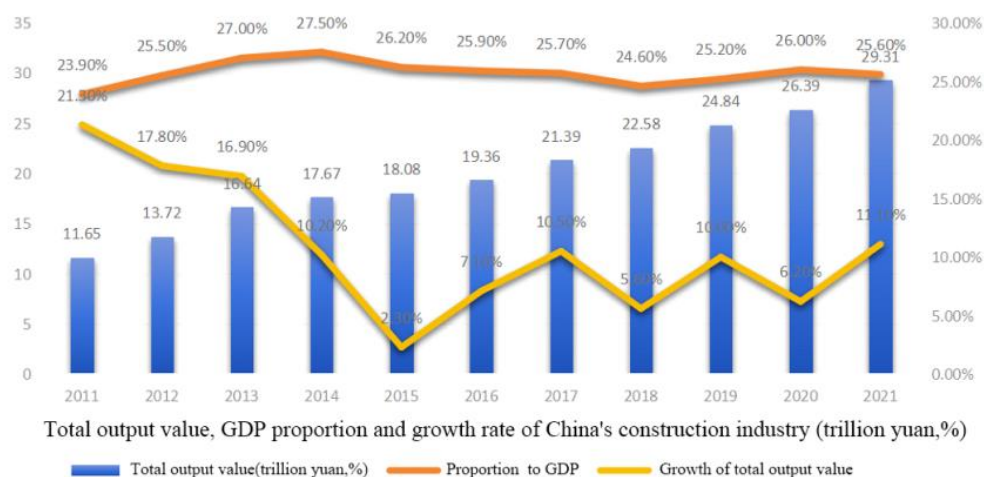


Figure 1: Overview of China's Construction Industry from 2011 to 2021^[1]. (modified by authors)

Our country highlight the promotion and application of BIM, the core value of which is to integrate building data and process data of building project. Nowadays, construction industry in China still has a high output, with the transforming of real estate, the output of construction industry will fell down, employment in the construction will also become difficult. However, the design and management of

construction industry is still very traditional, The BIM teaching in colleges and universities is still mainly based on the BIM theory explanation or the operation and modeling of BIM software, the whole-process application teaching of BIM in practice projects is not deep enough^[2]. Top-down management mode is usually adopted in the process of project implementation. Although information can be summarized, it is only limited to a small range of point applications in project quality, safety and other aspects^[3]. Therefore, according to the development and construction needs of the “Belt and Road”, and to achieve the goal of the transform for construction industry, it is necessary to utilize practical projects to promote BIM technology. The difference can be seen in Figure 2. Besides, through the digital twin work, the massive real-time data of various professional equipment is integrated, and the real-time data of the Internet of Things and the BIM model are effectively integrated to achieve building visualization and intelligent control^[4], which is also means a lot for building industry.

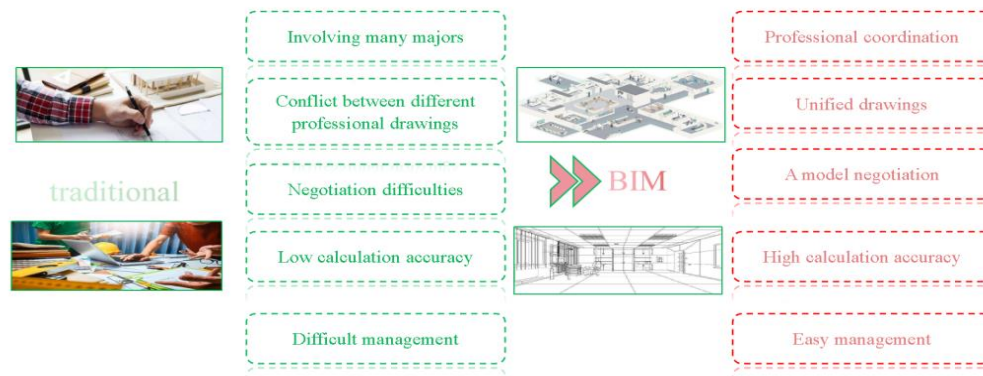


Figure 2: Comparison between traditional method and BIM method.(drew by authors)

2. Research methods and example

2.1. Research methods

This research will use literature research, case analysis, empirical research and other methods, comprehensive use of BIM technology, project management theory, information technology and other related knowledge, making deep research about Dongjiageng community placement room project. After that, AHP and fuzzy comprehensive evaluation were used to evaluate the application of the open platform in the project and the promotion of the open platform in the future teaching, and conclusions were drawn and analyzed.

2.2. Brief introduction of example

Dongjiageng community placement room project is an important people's livelihood project which involves a lot of demolition and resettlement. This community located in Jianyang city, Chengdu, which is a new gateway to the west and south of our country, a new platform for the construction of Chengdu-Chongqing Economic Circle. Tianfu International Airport adjacent to the area, government affairs, cultural and creative groups, innovative science and technology groups around, which gives a complete layout. Based on current residential place, the places will enhance the function and drive the development of the surrounding. New function will be implantation, combining with the original logistics, to form the transformation functional block of modern medicine and agriculture. Overview of the overall situation around the planning area is illustrated in Figure 3.

This project aims to provide and improve high quality of living conditions, give a better environment of local residents, promoting a sustainable community. In future, several metro lines had already been designed nearby, and one station close to this district, after infrastructure being finished, the people living nearby will have a convenient life, and can go out easily with beautiful scenery. The project is located in the eastern New Area strategy position is extremely important, which means the project has a significant meaning. But that project has much problems, it can be seen from Figure 4, and the detail of which is as follow:

(1)The project is a livelihood project, but it experienced the combination of official government institution and epidemic covid-19, which delayed the date of project deadline.

(2) In the process of this project, considering the significance of a livelihood project, the cost should be conducted, the project needs for clearer cost estimates than before.

(3) The requirement of Low carbon development.

(4) It requires to use a 3D online modeling to make it more efficiency and visual.

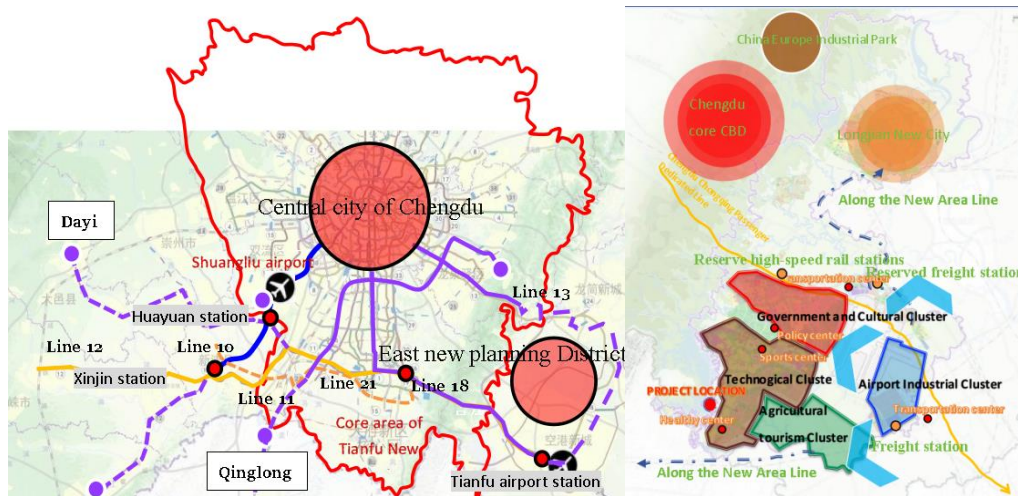


Figure 3: Overview of the overall situation around the planning area.(drew by authors)

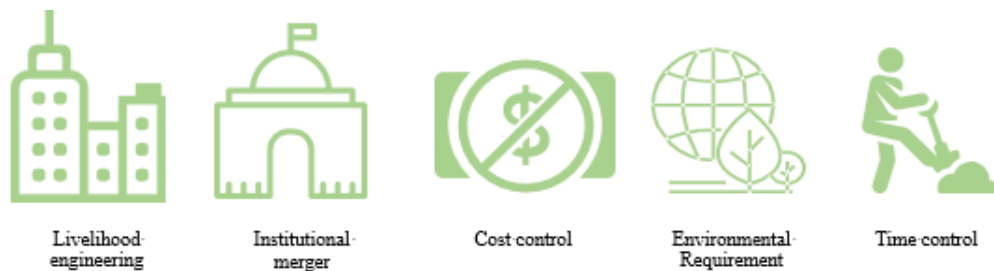


Figure 4: Overview of the overall situation around the planning area.(drew by authors)

3. BIM application situation of Dongjiageng community placement room project

3.1. Achieve the goal of quality, cost, schedule

Firstly, systematically improving the design quality. BIM comprehensive application research group of Dongjiageng phase I project was established, promoting special research on industry and university, assisting the construction company and the design institute to complete the BIM design process. Based on the precise mapping control system of BIM, the 3D control scheme of project is established to improve the spatial control ability. Using real-time 3D space simulation, intuitively feeling the internal space effect, can facilitate real-time annotation and communication shown in Figure 5. In the collaborative work mode, real achieved the multi-directional construction synergy. These action improved the communication efficiency, optimizing the detail design, refining model components.

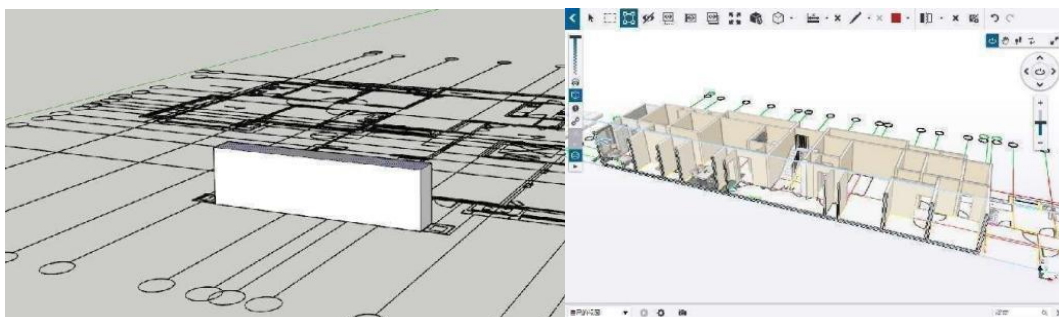


Figure 5: Component diagram of forming groups according to the specific parts.(drew by authors)

Furthermore, reducing the cost of project management. Because Trimble for Sketch Up is totally free open platform, so this research do not need to pay basic function. The project choose an industry-university-research mode, making a combination of teacher and students' class, which saving the cost of workers. During the modeling work, buildings was split into different components, and the amount of component production, which can give a more clear price of our buildings. Simulating the construction site staking plan based on BIM model, and then according to this plan, carrying out a more reasonable material staking and purchase scheme than before, so as to improve the construction efficiency. Thus, a clearer plan can make a better time scheme, which can give a better control of the time about material entry and exit, finally to achieve the purpose of shortening the construction period.

Additionally, a visual information data management system can help it a lot in the manage field. Based on BIM platform on Trimble connect Sketch up, it can give an online display of word, PPT, CAD, sketch up documents. Using the function shown in Figure 6 of examine and approval, it realize the requirement of different data summery from each participant, and can see each part of the project easily. By using the online system, promoting BIM team work, discussing problems in project, marking the model promptly, the project gradually finished a communication mechanism, and the team use the platform to see the latest condition, which create an efficient working atmosphere.



Figure 6: The main function display of Trimble.(screenshot by authors)

Finally, this project gives a sample for decoration and living condition. Using online sketch up model, combining with Lumion's function of instant rendering and simulation modeling, it lays some examples for the subsequent vegetation garden construction and house design of the community.

3.2. Design based on Trimble Connect of BIM workflow, Promote the whole process of cost

First of all, making fully use of the advantage of the software. Regular team assessment and feedback mechanisms are also indispensable to timely adjust training plans and teamwork strategies^[5]. Trimble's online platform can be easily used as an plugin loading in Sketch up. The registration of online open platform is easy, emails like QQ-email, hotmail, Gmail can use to enroll. The operating interface is very simple, the items show the all functions which have “to do”, “activities”, “teams”, etc., which is demonstrated in Figure 7. So, based on the functions mentioned above, by making a responsibility list and a daily report and supervision system, the research team finished the project well.

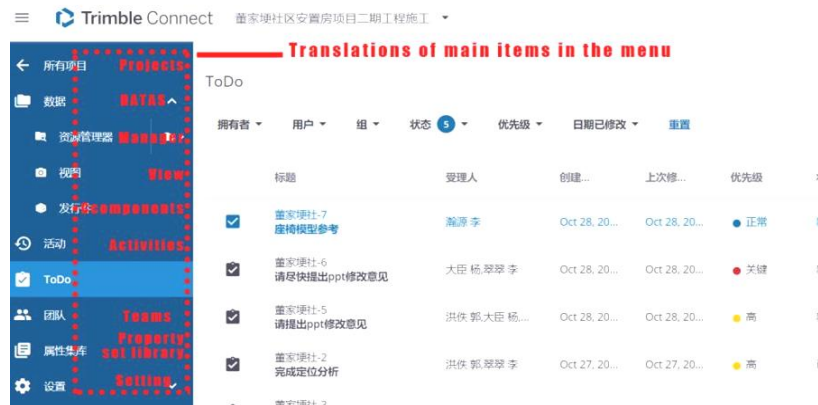


Figure 7: The main operating interface and its translation of Trimble (modified by authors)

In addition, the research team using cross-platform software to simplify the BIM model and optimize the construction cost. Because Trimble do not have the function of the list and determination of the cost, the Glodon, as a cross-platform which have a software of the national list quota, can give an existing Sichuan list quato exported as an excel to calculate the cost. In order to optimize the cost of structure, the decoration engineering, and the pipe network, the research team make up a three levels cost plan. To use a sketch up plug-in called Quantifier Pro can easily attach the cost to the main building and analyze the BIM model. Our building, by using this plug-in during the whole management process, can give a visible cost about each components which is a merit to control the total cost of the buildings. To simplify the whole work and save the time in the life cycle, using a single component to replace the original one adding on the cost by Quantifier pro, which make the model much more lighter. Thus, a standardized model building procedure was set up.

Admittedly, there still has some barriers in cross-platform work, but via promoting the whole construction online life cycle management control, the traditional thinking and working mode have changed a lot. Linking with the smart phone app, Email for example, a series of work have been built as an online checking system. Because of the platform has a function of online browsing, the reply can easily be given. Word, Sketch up model, PPT, Pictures all can be seen in the cell phone. As is shown in Figure 8, for the research team, online operating process is a unique attempt for our project. But it really save the time and give an efficiency for the whole team.

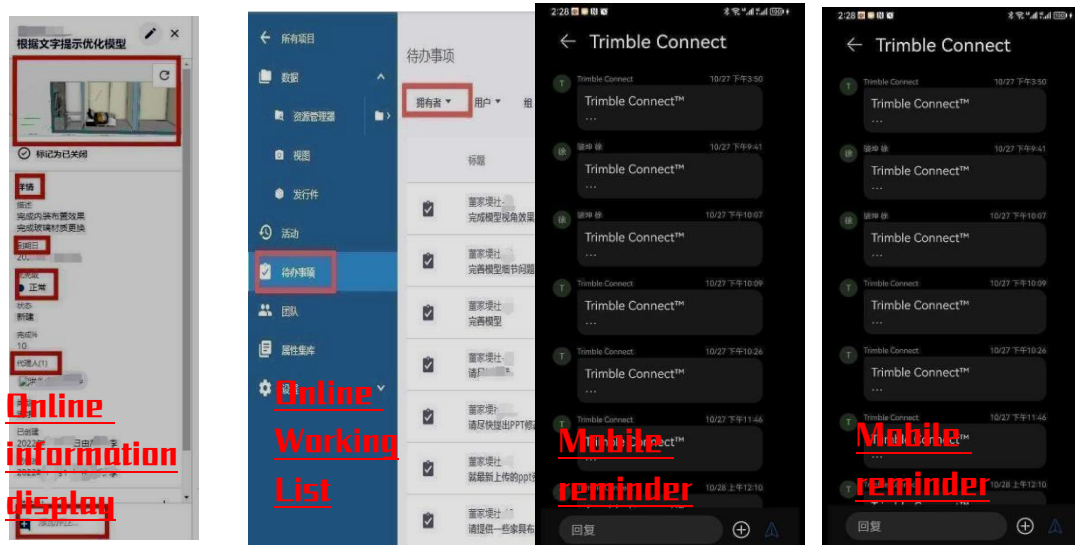


Figure 8: The main collaborative function of Trimble. (modified by authors)

Finally, this project gives a sample for decoration and living condition. Using online sketch up model, combining with Lumion's function of instant rendering and simulation modeling, It lays some examples for the subsequent vegetation garden construction and house design of the community. After that an animation was built to show how to construct and how to arrange the construction site, It directly shows the construction renderings of courtyard space and interior space of house type. By using this kind of deeper design, giving a better display effect of internal space.

3.3. Building an Industry-university-research mechanism, finding the way to construction of industry and university bases

Since the project relies on the BIM studio of Hope College of Southwest Jiaotong University for practical training and scientific research, the project team has also completed part of ways to the industry-university-research integration mechanism.

Double-qualified teachers(teachers who has working experience in an enterprise), enterprise mentors and government leaders jointly participate in the project research. By revising the teaching scheme, optimizing the basic BIM modeling courses, integrating the “1 + X” certificate corresponding to the innovation and entrepreneurship management curriculum system. Engineering management teacher provide professional theories and knowledge for teaching, projects and software are using for scene or examples, students can learn BIM modeling by using an almost real project cases. The enterprise manager is responsible for enterprise communication and docking, teaching and bringing enterprise management knowledge to the project and give cases for teaching. The government leaders explained the latest management policies, analyzed and described the needs of national transformation, informed the information of the industry development and the application of BIM at the present stage, and also provided students with some new understanding.

By these work, optimizing the student assessment mechanism of students. After the training through the project, encouraging them to participate national BIM competitions, using BIM studio as a base for technical study, feed back the practical results to the competition, forming a virtuous cycle. The students who take part in this project actively sign up for the “The ninth National College BIM Graduation Design Innovation Competition”, and won the third prize in 2023. After that, them use the knowledge the had to teach students in lower grades. Those students in lower grades take part in “The tenth National College BIM Graduation Design Innovation Competition”, and won prize too. On one hand, the students had gained the skills of communication and softwares. On the other hand, the students add practical skills and honors on their life which is helpful to find jobs after their graduation. That is really good for promoting optimize the teaching system. Besides, this cultivation mode promotes personalized talent training and job highly matching, which can reduce the loss of enterprise quality employees, providing mature, stable and reliable applied talents for enterprises^[6]. The team work is shown in Figure 9.



Figure 9: Pictures of Students training for Trimble. (taken by authors)

4. Discussion on the project management application based on the open platform

To sum up, Trimble is very suitable for a project management and has extensive applicability. It is very convenient and easy to learn, and also has good effect on teaching. But although the platform is convenient but the function of which is not as perfect as the Golden. The Golden has much more functions. How to choose and use an open platform in project and teaching is very essential for every students and workers. Thus, to make an evaluation from different aspect, and form an evaluation system is very important.

Considering different projects have different requirements, based on characters in this project, the convenience, applicability, functions, cost, safety, operative difficulties were used as as evaluation indexes. Software, like Goldon, luban Motor, PMS in our country already have a very complete system. From all of them, Goldon is the most complete one which has more than 100 softwares, and it have to learn a lot to use these software, so it can be used as an example to make a comparison. Convenience is the requirement for software installation, For example, software like Glodon takes up a lot of space, Update it timely, Also requires many installations. Generally bound mobile phone account can log in, Trimble's open platform can be directly connected by email, Installed as a plug-in of sketch up, Login at

the web address, And can provide mobile phone mail binding function, Do not need to download a special APP; Applicability is the ability of different software to adapt to different projects, Different applications have different characteristics, At the same time, Party A also has different requirements, Judging the applicability of the software application to the project according to the different project characteristics, At the same time, considering the applicability of the construction, road, municipal and other projects to judge; Functions is to consider how much things a software can do in the project, The richer the functions are, The more things that can be done, More able to make the project requirements to do more perfect; Use of costs partly affects the choice made by the boss, Many software now need to pay for membership to open specific functions, which will cost a lot for extra money; Safety is to consider whether the use of the software is safe and reliable, whether the storage data can be attacked and leaked; Finally, the difficulty of starting up will affect the efficiency of the use, operative difficulties also plays a role in platform choosing.

4.1. Evaluation analysis of this project software based on hierarchical analysis

Because the AHP method is applicable to the complex evaluation system, which is applicable to the existence of subjective situation. It is very applicable to urban and rural planning and engineering management, and is a widely used method to determine the weight. Therefore, according to the AHP method, to carry out a detailed analysis. Since this project is a practical project handled by professional manager, the management BIM lecturer is invited to score and evaluate together. Summary results of the judgment matrix are summarized in Table 1 and Table 2.

Table 1: Judgment matrix of this project-Part A.

Items	convenience	applicability	functions	cost
convenience	1	1	5	1/3
applicability	1	1	3	1/3
functions	1/5	1/3	1	1/5
cost	3	3	5	1
safety	1/3	1/5	1/3	1/5
operative difficulties	1	5	3	1

Table 2: Judgment matrix of this project-Part B.

Items	safety	operative difficulties	feature vector	weighted value (%)
convenience	3	1	1.931818182	17.56%
applicability	5	1/5	1.795454545	13.86%
functions	3	1/3	0.863636364	7.02%
cost	5	1	3.068181818	31.12%
safety	1	1/3	0.409090909	4.84%
operative difficulties	3	1	2.272727273	25.59%

At the same time, based on the implementation plan of Trimble sketch up platform and Glodon platform, evaluation can be obtained, Table 3 with the following results. Through the calculation of the score of Trimble and Glodon is 0.7467 and 0.2533 respectively. Therefore, it can be seen that the management experts of this project tend to use Trimble in the whole progress. It can be seen that the cost, operative difficulties and convenience are the three most important evaluation indicators of this project. In the context of this project, Trimble sketch upcan meet the requirements of this project.

Table 3: Presents the results based on the scoring of the two platform.

Convenience	Trimble	Golden	Applicability	Trimble	Golden	functions	Trimble	Golden
Trimble	1	5	Trimble	1	3	Trimble	1	1/5
Golden	1/5	1	Golden	1/3	1	Golden	5	1
Cost	Trimble	Golden	Safety	Trimble	Golden	operative difficulties	Trimble	Golden
Trimble	1	5	Trimble	1	1/3	Trimble	1	5
Golden	1/5	1	Golden	3	1	Golden	1/5	1

4.2. Evaluation and analysis on application of Trimble in teaching

In view of the long-term promotion and utilization in project and teaching, students need to make comprehensive evaluation and judgment, so a questionnaire survey was made based on students' evaluation of the two software. 10 points were scored as the total score, and the set C= was established, corresponding to the following table: {Great, Good, Average, Poor}, shown in Table 4.

Table 4: Corresponding scores and surveys of the fuzzy comprehensive evaluation.

Level	Great	Good	Average	Poor
Corresponding score	9-10	6-8	3-5	0-2

Through the design questionnaires survey, analyze the project students for the six indexes above, the result of the design questionnaires in shown in Table 5, Table 6. By calculation, It is concluded that the reference weights of the six projects are 22.79%, 17.93%, 22.44%, 11.23%, 14.48% and 11.13%. Then, conducting the fuzzy comprehensive evaluation, after the calculation, the analysis results of the questionnaire are as follows, and the evaluation results of Sketch up and Goldon are in Table 7.

Table 5: Results of Trimble questionnaire evaluation on BIM teaching use.

Level	PERFECT	GOOD	NORMAL	BAD
convenience	54%	19%	27%	0%
usability	27%	54%	19%	0%
functions	31%	50%	15%	4%
cost	46%	35%	19%	0%
safety	42%	38%	15%	4%
Operative difficulties	42%	42%	12%	4%

Table 6: Results of Goldon questionnaire evaluation on BIM teaching use.

Level	PERFECT	GOOD	NORMAL	BAD
convenience	45%	32%	23%	0%
usability	45%	41%	14%	0%
functions	59%	27%	14%	0%
cost	14%	55%	27%	5%
safety	45%	27%	14%	0%
Operative difficulties	23%	55%	18%	5%

Table 7: Final results of the fuzzy synthesis of Trimble and Golden software.

	variable	ratio		variable	ratio
Trimble	Perfect	0.317	Golden	Perfect	0.313
	Good	0.312		Good	0.313
	Average	0.317		Average	0.312
	Poor	0.054		Poor	0.062

It can be seen that after the comprehensive evaluation, the final evaluation of Trimble and Glodon is good. In the teaching process that can be well used, there are high evaluations of open BIM education and teaching. Generally speaking, the praise coefficient of Trimble is high, while the poor evaluation of Gloden is slightly higher. Generally speaking, the gap is not large.

4.3. Suggestions and thoughts on the application of BIM public Platform

4.3.1. Overall evaluation and analysis

In general, using the BIM open platform for engineering project management is a relatively good experience, which has achieved a high prize. It should be said that the application scenarios of BIM software still has differences between students and social users.

Each project has their own specific requirements, this project requires highly in the operative difficulties and use of cost. Sketch up in the most recognized is its convenience, the data is 54%, compared with Golden in functions won the biggest praise. Small storage space needed, convenient to install, easy to implement the requirements of the BIM, is the actual benefit to project utilization. In contrast, the most recognized aspect of Glodon is its complete functions mentioned above, with 59% data and more than 100 software, which can meet the construction, teaching, animation, schedule and other functions, in terms of multi-directional functions and high-demand BIM applications. In addition, sketch up received good praise in terms of cost, safety and operation difficulties, while the Glodon software achieved a good evaluation in terms of convenience, applicability and safety.

4.3.2. The promotion of BIM should be promoted in combination with the project need

The design of past BIM platform has many limitations, the establish of a platform was only for a certain aspect of management or a certain enterprise's needs and did not apply to all scopes. So most of the other work could not be carried out on the designated BIM platform or some functions of BIM platform is not needed, which caused the waste of the platform^[7]. In this project, the project team built a preliminary model based on the sketch up. While the project had a high degree of urgency. Trimble's instant mail function can be very good on the mobile phone to remind, feedback information, with high convenient real-time display, ranging, cut section and other functions. Its functions are also in line with the characteristics of the company's architectural designers' requirements. It can be seen that the future BIM technology should be based on the characteristics of the company's projects and the needs of characteristic projects, rather than the comprehensiveness of functions or the simplicity of the interface. In order to promote the further development of BIM technology, it should be highly analyzed for what the situation are in a project.

4.3.3. Promote multi-party participation in the application of BIM according to local conditions

In fact, the use of BIM involves various participation, the current domestic first, second and third tier cities makes no effort to promote the use of BIM. But there are enormous construction enterprises, design enterprises, official management agency, and the life cycle of a building contained a lot which is a complicate system. First-tier cities, for the reason that it have good foundation and high official financial support, BIM promotion is the most mature. But for other cities, traditional manage method and fake BIM more, and there is few BIM use in management progress. Second and third tier cities, because of the limitation of urban development and talent restrictions, BIM promotion is slow. This time, the practical experience of BIM management using the Trimble+ mode, based on the most sketch up software, gives a convenience. For government personnel, they can also observe online in real time and coordinate management, lowering the threshold of the industry. One of the reasons for the low efficiency in project management of architecture industry is that the loss of information caused by the poor information transmission^[8]. The Trimble Sketch Up using a straight visual method to deliver different participates' opinions, which ensures the true effectiveness of information transmission. It can be seen that the

operation of BIM platform requires the participation of all parties, and the application of BIM can meet the local needs and adapt local conditions.

4.3.4. Promote students to learn diversified BIM knowledge learning

At present, students in vocational education and ordinary undergraduate education are often confused by complex and huge software functions in BIM, with slow learning process. Nowadays, the high performance of student computer equipment has been popularized, the internet environment in the campus is also perfect. In addition, some students may also be fascinated by the cool modeling, video and other visual functions, and ignore the application of BIM in the cost, unified management, collaborative promotion and other manage fields. This deviates from the original meaning of the BIM concept promotion. Therefore, the application of BIM in management should be highly enhanced. More diversified BIM knowledge promotion in education and teaching can be finished in the future. Since the management platform and management operation of BIM are relatively convenient, it is suggested to use a small part of the BIM to explain the management application of the practical BIM, so as to enrich the education and teaching classroom.

5. Conclusion

Through the in-depth research and evaluation of the application of BIM open platform in the Dongjiageng community placement room project. It is not hard to find that the introduction of BIM technology can not only notably improve the efficiency and quality of project management, but also give a powerful support for the whole life cycle in engineering management.

In Dongjiageng community placement room project, BIM open platform achieve the integration and sharing, so that the project participates can real-time and accurately obtain the project progress, cost, quality and other key data, which make more scientific and reasonable decisions. At the same time, the visual features of the BIM model also provide intuitive and convenient communication tools for the whole project life cycle, which greatly reduces the communication cost and time cost caused by information asymmetry.

Still, there still have a lot of challeges using BIM technology in project manage progress, such as how to choose the function, which standard to use, and the way to developed the talent. So, in the future, while using the BIM in the field of construction work, attentions should be paid in whole project life cycle to find a solution to solve the problems. A lot of work should be done, strengthening data security management, establishing data backup and recovery mechanism; promoting the formulation and implementation of BIM standards, improving the degree of industry standardization; conducting talent training, and providing strong talent guarantee for the promotion and application of BIM technology.

In a word, the application of BIM open platform in engineering project management has broad development prospects and important practical significance. With the continuous progress of technology and the accumulation of application experience, it is believed that BIM technology will play a more important role in the future engineering project management, and make greater contribution to the sustainable development of the industry.

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China Society of Electronics and Labor “industry and education integration, school-enterprise cooperation” education reform and development topic, NO.Cea12023016.

References

- [1] Eastmoney.com. One day to study an industry: an in-depth analysis of China's construction industry market [EB/OL]. [2022-07-15] <https://caifuhao.eastmoney.com/news/20220715133440867483360>
- [2] Song Xiaogang. Research on BIM collaborative Innovation Teaching system of university Engineering Management [J]. *Project Management Technology*, 2021, 19 (01): 36-40.
- [3] Li Ke, Yun Zehui, Liu Chen, et al. BIM Common Data Environment thinking and practice [J / OL]. *Information Technology for Civil and Construction Engineering*, 1-6 [2024-07-29]. <http://kns.cnki.net/kcms/detail/11.5823.TU.20240613.1315.014.html>.
- [4] Wang Yulin, Zhao Yulong, Guo Jin. Research on the application of BIM technology in construction engineering [J]. *Research on Urban Construction Theory (electronic version)*, 2024, (17):82-84.DOI:

10.19569/j.cnki.cn119313/tu. 202417028.

[5] Ni Yanling, Tu Jiaxin, Zhou Wentao, et al. BIM industry-university-research collaboration practice and innovation under the new engineering concept [J]. *Quality and Market*, 2020, (13): 118-120.

[6] Jiang Lin, Zhao Mengyi, Pan Hui, et al. Investigation and analysis of BIM Technology Promotion Policy and Practical Application in China's construction industry [J]. *Building Structures*, 2024, 54(08): 141-151.DOI:10.19701/j.jzjg.20211942.

[7] Niu Bosheng. *Research on the application of BIM technology in engineering project progress management* [D]. Chongqing University, 2012.

[8] Bai Tao, Li Xinqiao. Research on the industry-university-research-application cooperation mode and approach based on the training of excellent engineering talents—— Take the architecture major as an example [J]. *Western Quality education*, 2016, 2(05): 36-37.DOI:10. 16681/j.cnki.wcqe. 201605023.