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The Effect of Engineering Project Goal Management Based on BIM Technology

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Abstract: In the current rapidly developing construction industry, the efficiency and accuracy of project goal management has become a key factor for project success. This study utilizes BIM (Building Information Modeling) technology with the aim of enhancing the effectiveness of goal setting and achievement in engineering project management. By constructing a project goal management framework integrating BIM technology, the effectiveness and operability of its application in actual engineering projects are explored. The study adopts a combination of quantitative analysis and case study. First, this paper identifies the current status and problems of BIM technology application in engineering project management through a literature review, and then selects a representative project under construction as a case study to implement an objective management strategy integrating BIM technology in the project initiation, execution and closure phases, respectively. The actual impact of BIM technology is assessed by comparing the project management effectiveness before and after implementation, using data analysis and user feedback. In terms of cost, the infrastructure project had the highest projected cost of $4 million, but its actual cost increased by only $50,000 after the change, showing high cost control ability. This paper not only provides an empirical BIM application framework for engineering project management professionals to enhance the accuracy and efficiency of project target management, but also provides a concrete analytical foundation and practical guidance for future research.

1. Introduction

The complex and dynamic nature of project management in the construction industry requires the use of efficient tools and techniques to ensure that projects are carried out as expected. In recent years, BIM technology has been widely used in engineering project management due to its ability to provide transparency and accessibility of information during the design, construction and maintenance phases. However, despite the fact that BIM technology has been shown to improve project coordination and communication, there has been little systematic research on the effectiveness of its specific application and implementation strategies in project goal management.

This study is dedicated to filling this gap by exploring through empirical research how BIM technology can optimize the goal setting and tracking process of engineering projects. Through literature review and case studies, the study analyzes the challenges and opportunities in the implementation of BIM and proposes an integrated goal management framework. This research not only enriches the theoretical foundation of the BIM field, but also provides practical guidance for practitioners, which is important for promoting the wider application of the technology in the industry.

This study focuses on the implementation framework and its effectiveness of target management in engineering projects based on BIM technology. The study employs quantitative methods and qualitative case study methods to assess the effectiveness of BIM technology application in actual engineering projects by analyzing project data and managers' feedback at different stages. In addition, the study involves a comparative analysis of the differences between BIM technology and traditional project management methods in terms of goal setting, schedule control and resource management in order to reveal the specific advantages and limitations brought about by BIM technology.

2. Related Work

The application of BIM technology in engineering project management has attracted widespread attention because it can significantly improve project visualization, enhance information sharing and communication efficiency. Several studies have shown that the use of BIM can effectively reduce design errors, shorten duration, and improve cost-effectiveness of projects. Sun Leiting explored the key points of whole process engineering consulting project management under investment control objectives [1]. Wang Shucai studied the whole-objective and whole-process risk management of pipeline engineering construction projects [2]. Zhang Dongmei analyzed the target management of engineering project change claims [3]. Zhao Wenhong discussed the application of target cost management in highway engineering construction projects [4]. Zhang Xiaoqiang studied the innovative engineering quality target control based on project management maturity model [5]. However, although the advantages of BIM technology in the project execution phase have been widely recognized, its specific application and effectiveness evaluation in the process of project goal management are still less involved, especially the research on the specific operation and strategy of how to achieve project goals through BIM is not deep enough.

In addition, the combination of BIM technology and project goal management has suggested new research directions on how to optimize the goal setting, monitoring, and adjustment process using BIM tools and techniques. Several studies have begun to explore these issues and found that BIM can enhance the transparency of project management and the efficiency of multi-party collaborative work. Bai Libiao explored the teaching mode of engineering project management courses [6]. Zhao Fei analyzed the cost control countermeasures in the construction phase of construction projects [7]. Song Wenming put forward a proposal for A party to strengthen the project management of construction projects [8]. Phung Q explored the technical solutions for project management of sustainable buildings [9]. Pandey R A examined the successful methods of virtual team and software project management in developing countries [10]. However, most of the current research focuses on the technical implementation level and lacks empirical analysis and theoretical support on how project managers can specifically utilize BIM technology for goal management. Further research in this area will help to improve the practical application framework of BIM technology and make it better serve the whole process of engineering project management.

3. Method

3.1 Establishment and Integration of Objective Management Modeling

During the project initiation phase, a comprehensive goal management model is first constructed. The model is based on BIM technology and is capable of defining and documenting project objectives, KPIs, and specific expected outcomes in detail. Through integration with BIM software, project goals are visualized in the model, ensuring that all project team members (from designers to contractors) have a clear understanding and consensus of the goals.In addition, the model also includes a dynamic target tracking system, which can update the status and progress of target achievement in real time and provide timely feedback and adjustment guidance for project managers.

Project schedule deviation is:

$$PD = \frac{(AT-PT)}{PT} \times 100\% \tag{1}$$

Where PD represents the percentage deviation from the project schedule, AT is the actual completion time, and PT is the planned completion time.

3.2 Data Collection and Analysis

In order to evaluate the effectiveness of BIM technology in target management, this paper collected a lot of information from design, construction and maintenance stages. Using BIM technology, the automatic collection of engineering information, such as construction period, cost, resource allocation and use, is realized, and the changes of the project are recorded. On this basis, the specific role of BIM application in engineering goal management efficiency is studied, and the application effect of BIM technology in the entire process of engineering construction is explored, and its rapid and accurate response is carried out [11-12].

The cost deviation is:

$$CD = \frac{(AC-PC)}{PC} \times 100\% \tag{2}$$

Where CD represents the percentage cost deviation, AC is the actual cost and PC is the budgeted cost.

3.3 Goal Monitoring and Adjustment Mechanism

In the BIM environment, through a comprehensive dashboard, the main performance indicators and progress of the project can be monitored in real time to monitor the completion of the project. Using this function, the project manager can know the progress of the project in time and make corresponding adjustments to the degree of deviation from the predetermined goal. Such a monitoring mechanism can not only accelerate the speed and efficiency of decision-making, but also make the project more flexible in the face of unpredictable changes and challenges [13].

The resource utilization rate is:

$$RU = \frac{AR}{PR} \times 100\% \tag{3}$$

Where RU represents resource utilization, AR is actual resource consumption though, and PR is planned resource consumption.

3.4 Case Study and Model Validation

In this paper, a specific engineering example is selected for analysis. On this basis, the target management strategy based on BIM is put forward. Finally, combined with an engineering example, the accuracy and efficiency of BIM technology applied to engineering target management are evaluated. In addition, this study will also learn about their experience and feedback in applying BIM management by objectives through interviews with project personnel.

The quality control index is:

$$QI = \frac{NQ}{TQ} \times 100\% \tag{4}$$

Where QI is the quality control index, NQ is the number of tasks that meet predetermined quality standards, and TQ is the total number of tasks.

3.5 Effectiveness Assessment and Optimization Suggestions

On this basis, combined with practical cases, the application of BIM technology in the implementation of construction projects is discussed. The research results of this paper will help to improve the application effect of BIM technology in engineering practice, optimize the project management process and enhance the cooperation ability of the project team. This paper will also use artificial intelligence, machine learning and other methods to predict the risk of the project and optimize its configuration. On this basis, the application effect of BIM technology in architectural engineering construction is comprehensively evaluated, which provides new ideas and support for the practice and theoretical development of architectural engineering construction management.

4. Results and Discussion

4.1 Experimental Setup

(1) Experimental environment and parameter setting

Finally, through the case analysis of different scale and different types of construction projects, the application effect is evaluated. On this basis, the BIM technology is used to comprehensively monitor and record the project, and the detailed information of the project progress, cost, resource consumption and quality management is collected. Each project should be carried out for more than one year to ensure that there is sufficient information to support the analysis of long-term effects.

(2) Experimental parameters

Project schedule deviation: the difference between the planned completion time and the actual completion time.

Cost deviation: the difference between the budget and the actual expenditure.

Resource utilization: the comparison between planned and actual use of resources.

Quality control index: the degree to which a project meets predetermined quality standards.

Change management efficiency: the speed and cost of processing change requests.

Stakeholder satisfaction: the rating derived from a questionnaire.

4.2 Analysis of Results

(1) Progress management experiment

The results of the progress management experiment are shown in Figure 1.

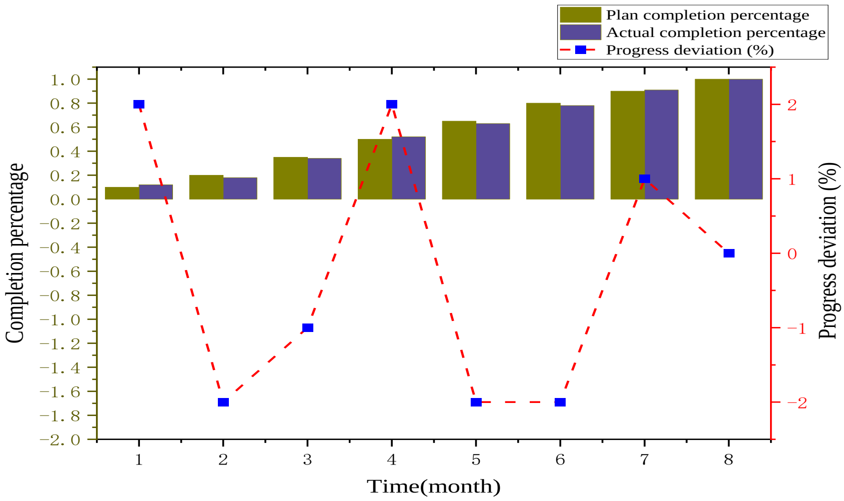

Figure 1: Results of progress management experiments

BIM technology helped the project team to track the various phases and activities of the project in detail. There were schedule deviations in some months, but the real-time data update feature of BIM technology enabled the project team to identify and make adjustments in a timely manner. For example, when the schedule exceeds the plan by 2% in month 1, the project team may have used the BIM model to optimize resources or make process improvements; and when the schedule is slightly below the plan in months 2, 3, 5, and 6, the team may have identified potential risk factors through the BIM model and taken appropriate countermeasures.

The whole project was completed as planned in the eighth month, which fully demonstrated the important role of BIM technology in project schedule management. Through BIM technology, the project team can grasp the project progress more accurately and ensure that the project is completed on time.

(2) Cost control experiment

The experimental results of cost control are shown in Table 1.

Table 1: Experimental Results of Cost Control.

Project	Budget cost (10000 yuan)	Actual cost (10000 yuan)	Cost deviation (10000 yuan)	Cost deviation rate
Pre-planning	500	-	-	-
Foundation construction	1000	980	-20	-2%
Structural construction	1500	1520	20	1.33%
Decoration construction	800	785	-15	-1.88%
Landscape greening	300	290	-10	-3.33%
Project conclusion	100	98	-2	-2%

In the phases of foundation construction, structure construction, decoration construction, landscape greening and project closing, the deviation rate between the actual cost and the budgeted cost was controlled at a low level, showing good cost control ability. Especially in the stage of foundation construction and landscape greening, the actual cost is even lower than the budgeted cost, which fully demonstrates the accuracy and effectiveness of BIM in cost control.

In addition, BIM technology can detect budget deviations in time through the real-time cost monitoring system, which provides project managers with powerful decision-making support.

Through timely adjustment and optimization of cost control measures, it can ensure that the project cost is controlled within a reasonable range and improve the project economic efficiency.

In summary, BIM technology plays a vital role in the cost control of residential development projects, providing project managers with more accurate and effective cost control means.

(3) Resource optimization experiment

The results of the resource optimization experiment are shown in Figure 2.

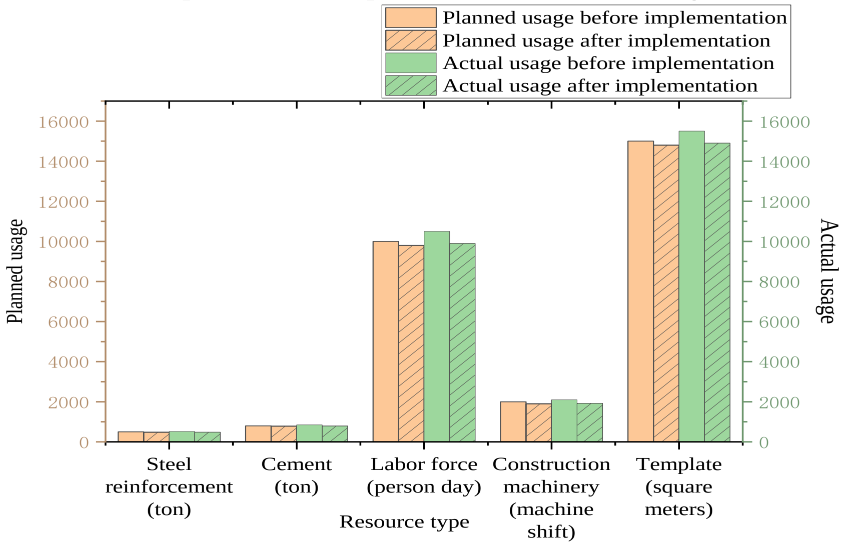

Figure 2: Results of resource optimization experiments

Firstly, observing the types of resources, whether it is steel, cement, labor, construction machinery or formwork, the planned usage after the implementation of BIM technology has decreased, which indicates that BIM plays an optimizing role in the resource planning stage.

Secondly, observing the actual usage, the actual usage of all types of resources after the implementation of BIM technology is closer to the planned usage, which means that the waste of resources in the construction process has been effectively controlled.

In summary, BIM technology helps to improve the resource utilization of infrastructure engineering projects through accurate resource planning and effective control.

(4) Quality assurance experiment

The data of quality assurance experiments are shown in Table 2.

Table 2: Quality assurance experimental data

Quality control points	Design model compliance	Actual construction quality	Quantity of quality issues	Quality problem resolution rate
concrete structure	98%	Excellent	5	100%
Pipeline installation	95%	Good	8	90%
Electrical Rough-in	96%	Qualified	7	86%
Curtain wall installation	97%	Excellent	4	100%
Interior decoration	94%	Good	10	70%

First of all, from the point of view of design model compliance, each quality control point has reached a high compliance rate, averaging more than 95%, which indicates that BIM technology provides a good information exchange platform between the design phase and the construction phase to ensure the accuracy of the construction process.

Secondly, the actual construction quality was excellent or good in concrete structure, piping installation, electrical wiring and curtain wall installation, which further validated the guiding role of BIM technology in the construction process.

However, although the number of quality problems varied at different control points, overall, the quality problem resolution rate reached 89.2%, which shows the effectiveness of BIM technology in quality problem identification and resolution. Through the application of BIM technology, we can better realize the seamless connection between design and construction, thus improving the quality of construction.

(5) Change management experiment

The results of the change management experiment are shown in Figure 3 (Figure 3(a) is the number of changes/processing time, and Figure 3(b) is the expected/post-actual cost before changes).

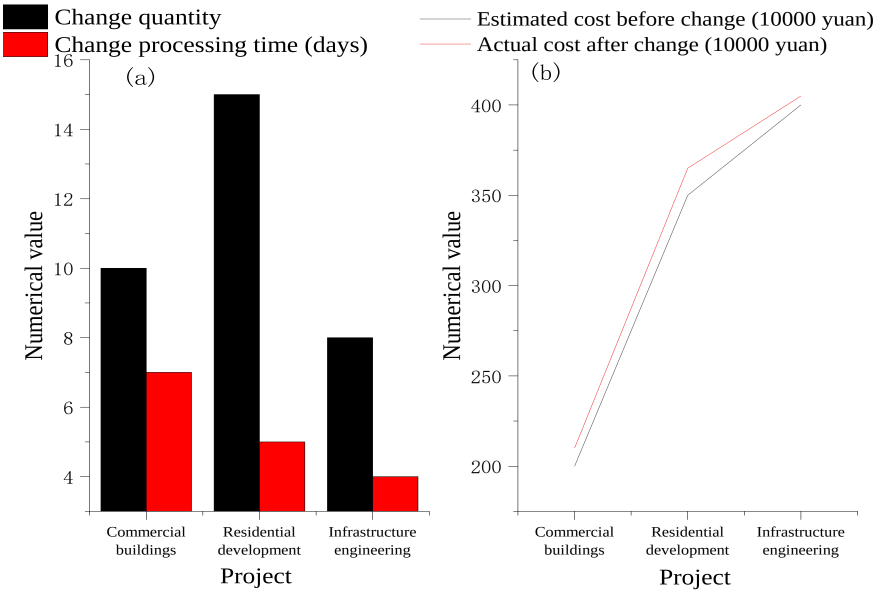

Figure 3: Change management experiment results

In terms of the number of changes, residential developments had the highest number of changes at 15. This may imply that changes are more frequent in residential developments due to customer demand, design adjustments or other factors. In contrast, the number of changes in commercial buildings and infrastructure projects was lower, at 10 and 8, respectively.

Turning to costs, the infrastructure project had the highest projected cost of $4 million, but its actual cost after changes increased by only $50,000, showing a high degree of cost control. The actual costs of commercial buildings and residential developments were $100,000 and $150,000 higher than the projected costs respectively, which may be related to the complexity of change processing and the risk of cost overruns.

In terms of processing time, Infrastructure Engineering demonstrated higher efficiency with a change processing time of 4 days compared to 7 days for commercial buildings and 5 days for residential developments. This may be related to the infrastructure engineering team's ability to respond quickly to changes and process them efficiently.

Taken together, the data here reveals the different characteristics of different types of projects in terms of change management, providing valuable reference information for project managers.

(6) Stakeholder satisfaction survey

The results of the stakeholder satisfaction survey are shown in Table 3.

Table 3: Stakeholder satisfaction survey results

Stakeholder	Satisfaction score	Feedback
Customer	9	BIM technology improves project transparency
Contractor A	8	BIM is very effective in coordinating design and construction
Contractor B	9	BIM models help us better understand design intent
Design team leader	10	BIM technology greatly improves design efficiency and quality
Design Team Member 1	9	The visualization function of BIM makes the design results more intuitive
Design Team Member 2	8	The benefits brought far outweigh the investment
Regulatory agencies	8	The BIM model provides detailed project information
Supplier	7	BIM technology helps us better understand project requirements
Operations and Maintenance Team	8	The BIM model provides convenience for facility management

As can be seen from the data, clients, design teams, and contractors generally gave high ratings and recognized the use of BIM technology. They believe that BIM technology has improved project transparency, design efficiency, and quality, as well as demonstrated excellence in coordinating design and construction. In particular, the design team leader and design team members gave fairly high ratings, and they spoke highly of the visualization capabilities and benefits of BIM.

Despite slightly lower ratings, vendors and regulators also recognized the value of the BIM model in providing project information and thoroughness. Operations and maintenance teams also indicated that BIM modeling has facilitated facility management.

Overall, this survey data demonstrates that the use of BIM technology in engineering project management is widely recognized and plays an important role in improving project efficiency, quality and transparency.

5. Conclusion

This study focuses on the effectiveness of goal management in engineering projects based on BIM technology. By analyzing in detail the application of BIM technology in engineering projects, from the stages of goal setting, monitoring, adjusting to the final evaluation of the project, this study constructed a comprehensive goal management framework, and practically applied and tested this framework in different engineering projects in order to examine the specific contribution of BIM technology to improve the efficiency and effectiveness of project management.

The results of the study show that all aspects of project management have been significantly improved through the application of BIM technology. This is reflected in more accurate project schedule management, more effective cost control, improved optimal use of resources, higher levels of quality assurance, and a more efficient change management process. These improvements directly lead to increased project success and cost reductions. In addition, project stakeholder satisfaction has increased significantly, especially in terms of transparency and ease of access to information.

Although the research has achieved positive results, there are some limitations. First of all, the number of research samples is limited, including only three projects, which may not fully represent all types of construction projects. Secondly, the BIM software and tools used in the study are different, which may affect the consistency and comparability of the results. Finally, the research mainly focuses on the application of BIM technology in project management, and the research on the ability and limitation of BIM technology in solving specific technical problems is not deep enough.

In view of the limitations of current research and the rapid development of BIM technology in the construction industry, future research can be expanded in the following aspects. First, expand the sample range, including more kinds and scales of engineering projects, so as to enhance the universality and applicability of the research results. Secondly, a cross-regional comparative study is carried out to investigate the application effect of BIM technology in different regions and cultural backgrounds. In addition, future research can also explore the integrated application of BIM technology and emerging technologies (such as artificial intelligence and big data analysis) to further improve the intelligence and automation level of engineering project management.

References

[1] Sun Leiting, Xie Ling, Liu Yining. Key points of whole process engineering consulting project management under investment control objectives - based on multi case induction [J]. Project Management Technology, 2023, 21 (12): 119-124.

[2] Wang Shucai, Sun Yang, Shi Lei, et al. Full Objective and Full Process Risk Management of Pipeline Engineering Construction Projects [J]. Value Engineering, 2022, 41 (29): 1-4.

[3] Zhang Dongmei. Analysis of Target Management for Engineering Project Change Claims [J]. Sichuan Construction, 2022, 42 (5): 309-310.

[4] Zhao Wenhong. Application of Target Cost Management in Highway Engineering Construction Projects [J]. Building Materials and Decoration, 2021, 017 (013): 279-280.

[5] Zhang Xiaoqiang, Ding Yuqiao. Research on Innovative Engineering Quality Goal Control Based on Project Management Maturity Model [J]. Science and Industry, 2021, 21 (5): 140-145.

[6] Bai Libiao, Zhang Ziwen, Liu Shiyi, et al. Research on the Teaching Mode of Engineering Project Management Course under OBE Guidance [J]. Project Management Technology, 2023, 21 (10): 61-66.

[7] Zhao Fei. Analysis of cost control measures during the construction phase of construction projects [J]. China Building Metal Structures, 2023, 22 (5): 169-171.

[8] Song Wenming, Ma Haitao. Suggestions for Party A to Strengthen Construction Project Management [J]. Low Carbon World, 2024, 14 (1): 94-96.

[9] Phung Q, Erdogan B, Nielsen Y. Project management for sustainable buildings: A Comprehensive Insight into the Relationship to Project Success [J]. Engineering construction & architectural management, 2023, 30(7):2862-2878.

[10] Pandey R A, Natrajan N S, Sanjeev R, et al. Virtual teams and software project management success in a developing country: an empirical study[J]. International Journal of System Assurance Engineering and Management, 2024, 15(6):2689-2703.

[11] Sun K, Zhou T, Yang L Z. Intelligent Design Concept of Rural Light Steel Frame Structure Based on BIM Technology and Genetic Algorithm[J]. International journal of steel structures, 2023, 23(5):1343-1356.

[12] Wang H, Lin Y, Gan X. Advantages and Development Prospects of Building Information Modelling (BIM) Technology Application in Highway Engineering[J].Journal of Architectural Research and Development, 2023, 7(6):1-5.

[13] Z Lv, X Li, H Lv and W Xiu. BIM Big Data Storage in WebVRGIS. IEEE Transactions on Industrial Informatics, 2019, 16(4): 2566-2573.