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A Study on the Usefulness of Enhancing the Teaching of Level Drawing Literacy in Architectural Design Using Computer Modeling Technology

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Abstract Building Information Modeling (BIM) technology has become an important development trend in the construction industry, but the survey shows that the application of BIM technology in most construction-type enterprises is still in the pilot stage. As a compulsory course for construction majors, the lack of practical experience of students restricts the teaching effect. Introducing BIM technology into the teaching of plain drawing is expected to make up for the traditional teaching deficiencies through three-dimensional modeling technology, improve the learning effect, and cultivate talents who are more in line with the industry needs. This study adopts the questionnaire survey method and experimental research method to investigate the application effect of computer modeling technology in the teaching of level drafting. The questionnaire survey shows that the average score of BIM technology application in the current construction type building enterprises is 74.24, 59.2% of the enterprises are in the pilot application stage, and only 7.9% of the enterprises are in the full-scale popularization and application. Multi-dimensional scale analysis shows that BIM talent training is one of the key factors affecting technology application. Based on this, the study designed a teaching program for plain drawing literacy based on BIM technology, including improving the practical training courses, developing information resources, carrying out skill competitions, constructing an evaluation system and improving the teachers' strength. The results of the teaching experiment showed that the posttest mean values of learning attitude, problem solving ability and skill mastery of the students in the experimental class were 3.90, 3.90 and 3.93, respectively, which were all significantly higher than those of the pre-test ($P<0.01$). The experimental class scored 4.25 points higher on the posttest than the control class, and the independent samples t-test showed a significant difference ($P=0.018<0.05$). The study proves that BIM technology can effectively enhance students' learning interest, problem solving ability, skill mastery and learning achievement in the teaching of plain drawing, which is of great value to the teaching practice of architectural design.

Index Terms BIM technology, leveled drawing, teaching effectiveness, problem solving ability, skill mastery, learning interest

I. Introduction

Plane method drawing is an innovation in the method of expression of reinforced concrete structural construction drawings, which is more symbolic and the expression is more standardized and digital, but requires beginners to master a large amount of symbolic information [1]. The main content of the course is to express the core elements of a house in plan representation, and the specific arrangement of reinforcement in the nodes between the elements [2], [3]. Students need to invest a lot of time to memorize the corresponding symbols and regulations in the preliminary study, and at the same time, they should be able to imagine the spatial pattern of reinforcement in the members according to the structural construction drawings, and calculate the length and number of reinforcement bars in various stress members of the building [4]-[6]. This course is a very practical course, due to the lack of practical experience of students, teachers rely only on lectures in the teaching process is difficult to establish the three-dimensional reinforcing steel skeleton system of housing components in the students' minds, and it is very difficult for students to learn [7]-[9].

With the increasing maturity of computer modeling technology development, at present, in the teaching process of domestic and foreign colleges and universities, a lot of practical subjects are used to modeling teaching software. Compared with the traditional classroom boring pure theoretical knowledge for teaching, students feel more intuitive under the guidance of modeling technology, can quickly integrate into the learning, naturally faster and better mastery of theoretical knowledge [10]-[12]. The introduction of this technology in the process of teaching the level drawing course, play its visibility, simulation of digital models and behavioral models, to make up for the shortcomings of the traditional architectural design teaching mode [13], [14]. In addition, students can also build their own building structure models, so that students can more quickly master the rules of flat law drawing while improving their hands-on ability [15]-[17]. As a result, computer modeling technology makes the classroom no longer full of lectures, and realizes the transformation of the teaching mode of "student development-oriented, hands-on practice-centered", which promotes the cultivation of vocational education and application-oriented skill-oriented talents.

Building information modeling (BIM) technology, as a method of building model construction based on three-dimensional digital technology, has become an important technical means for modern building design and construction management. This technology can provide coordinated information support for the whole life cycle of engineering projects, and can play an important role in all aspects from investigation, design to construction and operation. Currently, the global construction industry is undergoing digital transformation, and BIM technology, as one of its core driving forces, is being adopted by more and more enterprises. However, the application of BIM technology in China's construction industry still faces many challenges, especially in the training of professional talents, there are obvious shortcomings. Colleges and universities, as the main place for professional talent training, whether their teaching content and methods are adapted to the development needs of the industry is directly related to the employment competitiveness of graduates. As a core course of architectural specialties, plain drawing is crucial for students to engage in architectural design and construction work in the future. The traditional teaching of drafting is based on two-dimensional drawings as the main carrier, and it is often difficult for students to transform the information of flat drawings into spatial construction, resulting in poor learning results. At the same time, because students in colleges and universities rarely have the opportunity to directly participate in actual engineering projects, the lack of practical experience further exacerbates the learning difficulty. These problems have become bottlenecks restricting the improvement of the teaching quality of architectural specialties.

Based on the above background, this study intends to investigate the current situation of BIM technology application in construction-type architectural enterprises, analyze the current demand for BIM technology and related talents in the industry, and provide a basis for teaching reform in colleges and universities. On this basis, the study introduces BIM technology into the teaching of plain drawing, and designs teaching strategies including the improvement of practical training courses, information resource development, promotion of skill competitions, construction of evaluation system and enhancement of teachers' strength. By implementing BIM technology-assisted teaching in the experimental class and comparing it with the control class using traditional teaching methods, the impact of BIM technology on students' learning attitudes, problem solving ability, skill mastery and learning achievement is comprehensively evaluated. This study expects to experimentally verify the application effect of BIM technology in the teaching of level drawing, provide empirical evidence for the teaching reform of construction class professional courses, and at the same time explore effective paths for cultivating BIM technology-applied talents in line with the needs of the industry.

II. Survey on the current status of BIM technology application in construction enterprises

II. A. Sample Acquisition

BIM refers to Building Information Modeling, and BIM technology is based on three-dimensional digital technology for building modeling, which can provide coordinated, internally consistent, and computable information for project investigation, design, construction, and operation.

The data of the article was obtained by questionnaire survey method, and the questionnaire distribution method was simple random sampling method, which was carried out in the form of on-site interviews and mail distribution from the construction type building enterprises in city B. A total of 80 questionnaires were distributed, 80 were retrieved, 76 were valid questionnaires, the number of valid questionnaires meets the standard of large samples for statistical significance. 76 questionnaires were from 24 construction enterprises interviewed, including state-owned construction enterprises and private construction enterprises, etc., and the positions of the interviewees were as follows: 20 project managers, 35 technicians, 12 A-side supervisory personnel, and 9 other personnel. The questionnaire basically covers all the parties involved in construction enterprises, which can reflect the demand and application of BIM technology and other realities in a more comprehensive way.

II. B. Data descriptive statistics

This questionnaire mainly investigates the current situation of BIM technology application in construction enterprises from two major aspects: the basic survey of application and the survey of influencing factors. The questions of the basic survey are in the form of fill-in-the-blank questions, and the main investigation of the application of BIM technology in the enterprise is quantified into a total of 100 points. In order to better illustrate the extent of the application of BIM technology, this survey is divided into four categories of application, which are as follows: no advancement yet or only budding (0-59 points), conceptual application (60-69 points), project pilot (70-79 points) and promotion of application (80-80 points). 100 points).

II. B. 1) Basic situation analysis

The scores of the basic situation of enterprise BIM technology application are shown in Figure 1, and Table 1 shows the basic situation of BIM technology application of each surveyed construction category enterprise. The average score of the basic situation of enterprise BIM technology application is 74.24, and the values of skewness and mean as well as median indicate that the data has a similar normal distribution pattern, which means that most of the BIM technology application of construction enterprises is in the pilot exploration state, and the enterprises with very poor and very good application situation also exist, but they do not account for a large proportion.

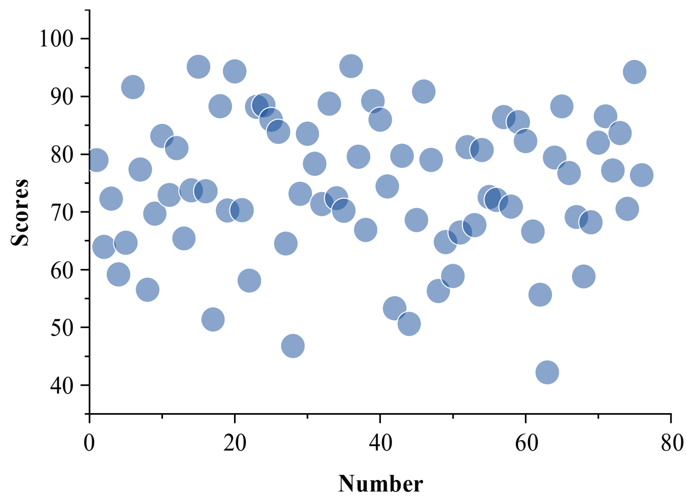

Figure 1: The basic situation of BIM technology application

Table 1: The description statistic of the basic situation

Index	Index value	Index	Index value
Average score	74.24	Min value	42.21
Median	76.95	Max value	95.25
Standard deviation	18.63	Degree of bias	0.31

Figure 2 shows the frequency distribution of BIM technology application, which further illustrates the quantitative distribution of BIM technology application scores. 32.9% of the construction enterprises have not yet started the pilot application of BIM technology, 54 enterprises in the pilot application stage, accounting for 59.2%, and only 7.9% of the enterprises in the full-scale promotion of the application, which is obviously at a more unsatisfactory level.

II. B. 2) Analysis of Impact Factors

The survey on the factors influencing the application of BIM technology in construction-type building enterprises adopts the form of scoring from 1 to 5 points, and is analyzed using the multidimensional scaling analysis method (MDS), and the visualization of the factors influencing the application of BIM technology is shown in Figure 3. The factors affecting the application of BIM technology in construction-type construction enterprises are obviously clustered into two categories: (1) The degree of matching of hardware, the maturity of software, the current project management mode, the cultivation of BIM talents and other indicators are clustered into one category, which all reflect the inadequacy of the hard indicators of the informationization operation of the current construction-type enterprises, especially the construction-type construction enterprises. (2) The rest of the indicators reflect the problems in the soft categories of government policy guidance, local market demand and cost investment risk, which are related to the market environment of construction enterprises' operation.

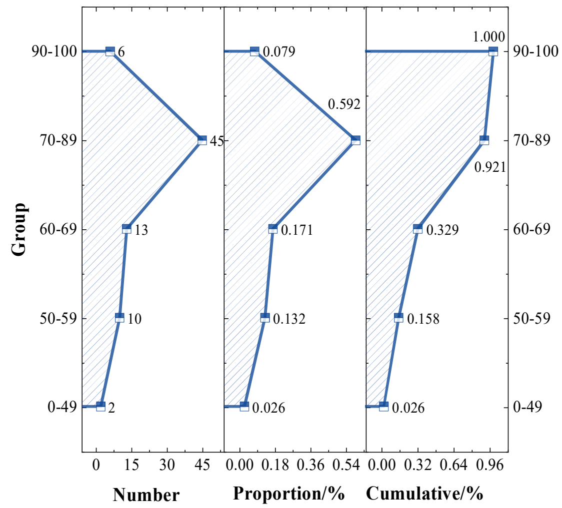

Figure 2: The frequency distribution of BIM technology applications

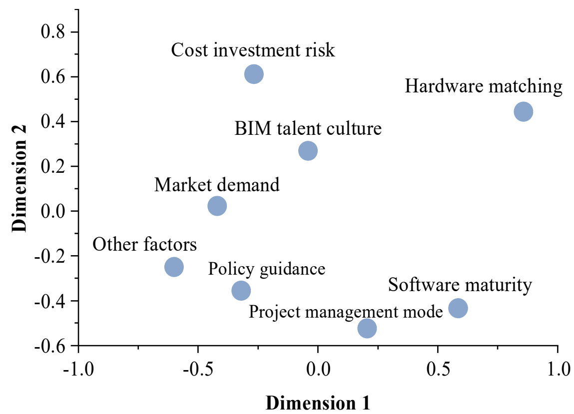

Figure 3: The impact factor visualization of BIM technology application

II. C.Teaching of plain drawing and BIM technology

Pingfa Literacy" course belongs to the compulsory courses for architectural majors, and the core of the whole course teaching is to show the dimensions and reinforcement of the main components of the building through the expression of the Pingfa, and according to the drafting rules of the planar overall representation method, which will be directly embodied in the plan layout, and finally form a complete structural construction drawings and other results. At present, it is difficult for college and university construction students to directly participate in the construction of engineering projects during their study period, resulting in the lack of practical experience of most students, and they are unable to construct the space of the drawing information introduced in the course of "Plane Literacy Drawing" in the classroom teaching, which has become a problem that can not be ignored in the classroom teaching.

Based on the application of BIM technology and the demand for BIM personnel training in construction construction enterprises, as well as the status quo of the teaching of plain drawing, BIM computer modeling technology is applied to the teaching of plain drawing, BIM technology can stereoscopically show the building model and various data information, to realize the combination of theoretical knowledge and practice, to stimulate the students' interest in learning, and to improve the teaching effect.

III. Exploring the teaching of leveled drawing based on BIM technology

III. A. Actively improve the practical training course program

The integration of BIM technology in the teaching of plane practical drawing, first of all, should be combined with the development dynamics of the construction industry and the demand for talents to improve the current teaching program. When carrying out practical training courses, the teacher can take the common engineering projects in life as the main teaching content, and use the Quanta BIM layer measurement platform to complete the construction of the three-dimensional model, and complete the three-dimensional modeling on the basis of the BIM to complete the development of the three-dimensional modeling practical training project.

Students can complete the construction of BIM model through customized drawing composition project settings, drawing input, CAD guide and other ways, and then complete the subsequent literacy and calculation of reinforcement. In the construction of the BIM model, the three-dimensional model can be constructed through the three-dimensional model to observe the three-dimensional layout of the reinforcement in the model, especially for some special component nodes can be more clearly and clearly shown, to help students master the basic rules of plain drawing, accurately read construction drawings, and then effectively reduce the difficulty of learning.

III. B. Comprehensive development of information course resources

Teachers can combine the BIM technology, in-depth development of the information course resources of "leveling drawing", for example, the development of microteaching video on the basis of BIM, fully given with the students' independent learning time, the use of PPT courseware to improve the teaching mode, the construction of three-dimensional model, to strengthen students' understanding of professional knowledge, and others include the development of the text as well as test question resources.

Teachers in the teaching process, teachers can combine online and offline mixed teaching mode to build a complete course teaching system. In online teaching, teachers can combine BIM resources to improve the online vocational education cloud platform, and upload the corresponding teaching resources, so that students can also watch such teaching resources after class. Or, build the micro letter public number of "plain drawing and reinforcement calculation", adopt the online platform teaching mode to provide students with more comprehensive teaching content. The offline teaching is to combine the specific content of the online pre-study, gradually solve the students' doubts, and at the same time upload the teaching difficulties in the offline classroom to the online micro-teaching platform, so that the students can realize their own learning content after class time. Students in the application of the online platform can also realize the real-time interaction with the teacher, to enhance the communication between teachers and students, the teacher in the arrangement of teaching tasks, can also be combined with the actual learning situation of the students, the rational design of teaching programs, and thus improve the effectiveness of education and teaching.

III. C. Promoting student skills competitions

In order to improve the practical ability of students' professional courses and ensure that their business level meets the needs of the industry, teachers can organize students to carry out small-scale BIM skills competitions or participate in BIM competitions carried out between schools to deepen the students' mastery and understanding of professional skills knowledge, and the students can be exposed to a more comprehensive knowledge of literacy and computation of the application of BIM technology in the process of preparing for the competition.

III. D. Reasonable construction of teaching evaluation system

The construction of the teaching evaluation system requires teachers in the context of BIM technology, fair evaluation of students' learning in the "leveling" course, in order to improve the effectiveness of teaching evaluation, for students' data analysis, modeling operations and other abilities to conduct a comprehensive exploration, in order to achieve scientific and rationalized evaluation. In order to quantify the teaching evaluation, diversified assessment and evaluation methods should be adopted, combined with the actual ability of the students to carry out a comprehensive assessment of plain drawing, and appropriately increase the proportion of the assessment of the BIM modeling practice, to enhance the practical ability of the students.

III. E. Continuous improvement of education teachers

Based on the BIM technology course teaching mode, teachers should master BIM technology, perfect their BIM skills, but also should master the steel three-dimensional training simulation software, Quanta software and other BIM software, constantly improve their teaching ability, enhance their professional training foundation level, so as to pave the way for education and teaching. Schools should actively carry out the corresponding education and training work, for the "leveling" course teacher team to carry out BIM technology application training work, so that they can master the relevant theoretical knowledge about BIM technology, improve the professional level. At the same time, teachers can also be encouraged to actively participate in the BIM skills competition, and obtain a certificate of BIM technology operation, so that the teacher strength can be continuously strengthened to provide students with professional teaching. In addition, the school can also actively promote school-enterprise cooperation, hire BIM technology talents with rich practical experience to work in the school or part-time, to enhance the school's teaching force and improve the teaching level.

IV. Effectiveness of the application of BIM technology

This chapter explores the practicality of utilizing BIM technology to enhance the teaching effect of leveled drafting in architectural design through teaching experiments.

IV. A. Subjects

The subjects of this study are the students in the second-year Construction 1 and Construction 2 classes of the Building Engineering Construction program in School M. Through the investigation and analysis of the students' learning status before the action study, it was found that the students in the two classes were roughly similar in terms of test scores, learning attitudes, problem solving ability and skill mastery in plain drawing, so the two classes were chosen as the research object, and the comparison between the two after the action study can better reflect the effect of BIM technology on improving their plain drawing ability. In this study, the first class of construction engineering, with 50 students in total, is taken as an experimental class to carry out the teaching of leveled drawing with the help of BIM technology. The second class of construction engineering, with 49 students, is the control class, which is taught by traditional teaching methods, and the teachers of the experimental class and the control class are the same teachers.

IV. B. Experimental design

After a semester of action research, the two classes were compared in the following 2 aspects:

First, two questionnaires, a pre-test and a post-test, were used to analyze the effects of BIM technology on the students in the Construction 1 class in terms of their learning attitudes, problem solving abilities and skill acquisition.

Second, the test scores of the students in the two classes were compared to analyze whether BIM technology would have a positive change on the students' performance in plain drawing.

IV. C. Data analysis

After a period of action research on teaching BIM technology, SPSS statistical software was used to organize and analyze all the data in the research process, including the pre- and post-test data of the questionnaire and the pre- and post-test data of the achievement test in the two classes.

IV. C. 1) Questionnaire results

By comparing and analyzing the survey results of the pre- and post-test questionnaires of the Construction 1 class, we understand whether there are any significant differences in the learning attitudes, problem-solving abilities and skill mastery of the students in the Construction 1 class after the teaching of BIM technology. The results of the survey on each dimension of the pre- and post-test are shown in Figure 4, the higher the mean score, the better the current status of students' learning, and the smaller the standard deviation, the smaller the gap between students.

The mean values of learning attitude, problem solving ability and skill mastery of the students of Construction 1 class before the action research were 2.49, 2.52 and 2.48 respectively, and the mean values after the experiment were 3.90, 3.90 and 3.93 respectively. It can be seen from the scores of the mean values of the pre- and post-tests that the scores of the post-tests are higher than those of the pre-tests, which means that there are significant improvements in the attitude of the students towards the learning of leveled graphic design and their problem solving ability There is also a significant improvement in the process of mastering the vocational skills of the position of level drawing, students have the ability to analyze and solve problems to a certain extent, while the degree of skill mastery has been strengthened. The standard deviations of learning attitude, problem solving ability and skill mastery of the students in the construction 1 class before the experiment were 0.862, 0.817 and 0.722 respectively, and the standard deviations after the experiment were 0.523, 0.404 and 0.523 respectively, and a comparison of the standard deviations of the dimensions can be seen that the standard deviations of the three dimensions have been reduced to varying degrees, which indicates that the pre-plaining literacy learning of the construction 1 class students with poor status quo have also made significant progress.

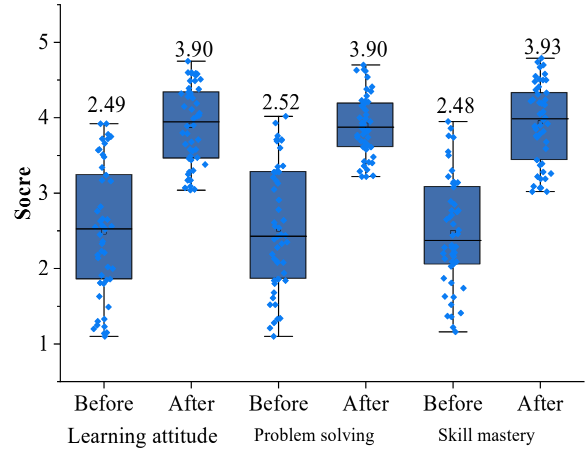

Figure 4: Survey results of each dimension before and after test

In order to further verify the significance of the change in the current status of students' learning of plain drawing, the researcher conducted a paired-sample t-test, which indicates that there is no significant difference in the current status of students' learning between the pre and post-tests if the significance (two-tailed) value of the t-test ($P > 0.05$) is significant, and, on the contrary, a significant difference in the current status of students' learning between the pre and post-tests if the significance (two-tailed) value of the t-test ($P < 0.05$) is significant and the P The closer the value is to 0 means the higher the significance. Pre- and post-test paired samples T-tests are shown in Table 2.Pair 1~Pair 4 refers to learning attitude, problem solving ability, skill mastery and overall situation. From the results of the overall pre and post-test paired samples t-test, the mean difference is 1.438, the lower limit of the 95% confidence interval of the difference is 1.652 and the upper limit is 1.264, and the t-value is 14.136, and the significance (two-tailed) is $P = 0.000 < 0.01$, which indicates that at the 1% significance level, there is a significant difference in the current status of the learning situation of the flat drawing literacy of the students of Class 1 of the Construction Engineering before and after the experiment, that is, the There is a significant improvement in the current status of plain drawing literacy learning of the students of Construction 1 class after the application of BIM technology.

Table 2: The matching sample t before and after test

		Mean	SD	SE	95% confidence interval		t	Sig. (Double tail)
					Upper limit	Lower limit		
Pair 1	Before After	-1.465	0.842	0.136	-1.722	-1.135	10.502	0.000
Pair 2	Before After	-1.392	0.755	0.173	-1.641	1.203	-12.327	0.000
Pair 3	Before After	-1.524	0.694	0.108	-1.708	-1.252	-13.986	0.000
Pair 4	Before After	-1.438	0.715	0.114	-1.652	-1.264	-14.136	0.000

IV. C. 2) Comparison of test results

The students in the two classes were tested for their achievements separately, and the results of the statistical analysis of the pre- and post-test scores are shown in Figure 5. There is no significant difference between the average scores of the two classes before the experiment, indicating that the level of plain drawing literacy of the students in the two classes is comparable. After one semester of BIM technology teaching, the post-test scores of the students in the Construction 1 class have been significantly improved, with the average score 4.25 points higher than that of the Construction 2 class and 6.2 points higher than that of the pre-test score, and the teaching of leveling method literacy with the help of BIM technology has positively stimulated the interest of students' learning, improved the problem-solving ability and skill mastery of students while Promoting effect.

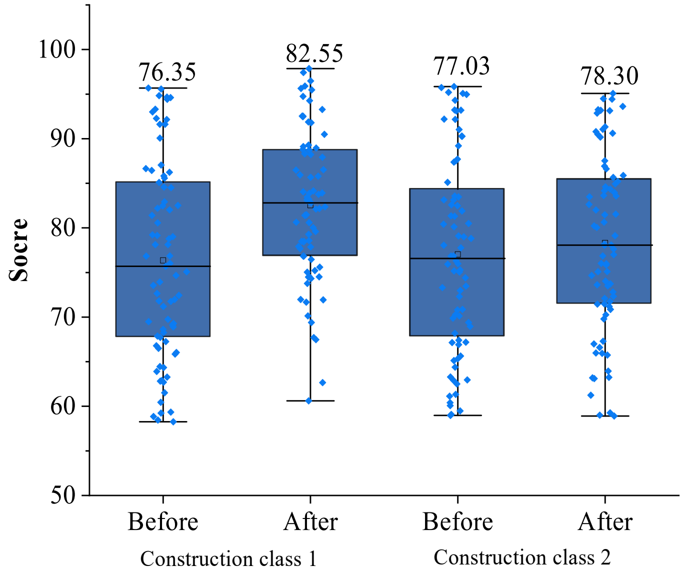

Figure 5: Statistical analysis of the before and after test results

In order to analyze whether there are significant changes in the test scores of the students in the two classes before and after the experiment, an independent samples t-test was conducted on the test scores of the students in the two classes, and the independent samples t-test of the pre and post test scores is shown in Table 3. The significance P = 0.574 > 0.05 and the significance (two-tailed) P = 0.627 of Levine's test of variance equivalence in the preexperiment test scores, both of which are greater than 0.05, which suggests that there is no significant difference in test scores between the two classes before the experiment. Levine's variance equivalence test significance P = 0.052 > 0.05 in the test scores after the experiment, so equal variances are assumed, and the significance of equal variances is assumed (two-tailed) P = 0.018 < 0.05, which indicates that there is a significant difference between the test scores of the two classes after the experiment, and that the Construction 1 class is significantly higher than that of the Construction 2 class, which indicates that the introduction of BIM technology into teaching has a positive and promoting effect on the improvement of the students' performance of leveled drawing literacy has a positive promoting effect.

Table 3: Independent sample t test before and after test

		Levin variance equivalence test		Average equivalent t test					
								95% confidence interval	
		F	Sig.	t	Sig. (Double tail)	MD	SE	Upper limit	Lower limit
Before	Assumed equal variance	0.035	0.574	-0.462	0.627	-0.680	2.759	-4.855	3.428
	Unassuming equal variance			-0.462	0.627	-0.680	2.548	-4.852	3.416
After	Assumed equal variance	3.292	0.052	2.908	0.018	4.250	2.229	0.639	9.437
	Unassuming equal variance			2.908	0.018	4.250	2.239	0.611	9.469

V. Conclusion

Through the research on the application of BIM technology in the teaching of leveled drawing, the following conclusion can be drawn: the application of BIM technology can indeed significantly improve the practicality and teaching effect of leveled drawing teaching. The experimental data show that after teaching with BIM technology, the mean values of students' learning attitude, problem solving ability and skill mastery increased to 3.90, 3.90 and 3.93, respectively, and the standard deviations decreased, indicating that the overall level of the class was improved and the gap between students was reduced. The paired-sample t-test results show that the mean difference between the pre and post-tests is 1.438, which is significantly different at the 1% significance level (P=0.000<0.01). Meanwhile, the posttest scores of the BIM technology teaching class were 4.25 points higher than those of the traditional teaching class, and the independent samples t-test confirmed that this difference was statistically significant ($P=0.018<0.05$). These results fully prove that BIM technology helps students overcome the difficulty of spatial construction by providing three-dimensional visualization models, effectively stimulates learning interest and improves the ability to solve practical problems. Teaching practice has proved that measures such as improving practical training course projects, developing information course resources, promoting skill competitions, constructing a reasonable evaluation system and improving teachers' strength have formed a complete teaching system of BIM technology, which can effectively cultivate technical talents to meet the needs of the construction industry.

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