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Exploring the practical path of green building concepts in housing product design education

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Abstract Currently, the traditional housing product design education model has problems such as the disconnection between theory and practice and the insufficient cultivation of students' innovative thinking. Green building concept, as an important part of sustainable development, has been increasingly emphasized in the field of architectural design. STEAM education, with its interdisciplinary integration and practice-oriented features, provides a new path for housing product design education reform. Based on the concept of STEAM education, this study explores the practice path of green building concepts in housing product design education. Methodologically, a controlled experimental design was adopted, two parallel classes with a total of 100 students were selected, the experimental class adopted the teaching mode of integrating STEAM education, and the control class adopted the traditional teaching mode, and through a three-month teaching practice, evaluation and analysis were carried out in four dimensions, namely, classroom time interest, professional core literacy, innovation and practice ability, and quality of works. The results show that the degree of interest in class time of students in the experimental class is significantly higher than that of the control class, with an average score of 37.051 versus 33.162; in the evaluation of professional core literacy, the average score of the experimental class is 12.623, which is significantly higher than that of the control class, which is 10.509; in the evaluation of the quality of the works, the proportion of excellent and good in the experimental class's work1 reaches 80%, while the control class only has 40%; the ability of innovative practice The comprehensive evaluation shows that the total score of the posttest of the experimental class is 39.322, which is significantly higher than that of the pre-test 36.43. The conclusion shows that the green building housing product design teaching mode based on STEAM education concept can effectively enhance students' learning interest, professionalism and innovative practice ability, and provides a feasible practical path for housing product design education reform.

Index Terms Green building concept, housing product design, STEAM education, innovative practice ability, professional core literacy, teaching mode

I. Introduction

Housing product design education is an important course in colleges and universities, aiming to systematically understand the method of housing product design and its expression of creative thinking, as well as to understand the development trend of it, so as to improve students' understanding of the concept of housing, strengthen their mastery of its design and creation methods, and guide them to bravely explore the unknown field [1]-[4]. The teaching content of the course includes understanding the concept and development of housing, the harmony between housing and the natural environment, and mastering the correct thinking process and expression of design creation [5], [6]. With the introduction of the “low carbon” policy, the concept of green building has been gradually applied in the education of housing product design in colleges and universities [7], [8].

The construction industry is an industry that consumes a lot of energy and resources, and the active implementation of green design concepts in the construction field will not only effectively reduce the impact on the environment, but also save a lot of economic costs [9]-[11]. The green building concept is to reduce the harm of the building to the natural environment through the use of renewable materials, the adoption of low-energy systems and the optimization of building design, such as the use of solar power, cold and heat pumps, smoke and air ventilation systems and other technologies, which can achieve the energy use of the building and carbon dioxide emissions reduction [12]-[15]. With the modernization, technologization and informationization development of society and the continuous improvement of people's living standards, the green building concept has become a standard in architectural design [16]-[18]. Especially in the design of housing products, it has also become an important part of China's current stage of architectural design must be part of the important part of the design review in the design review focus on the content [19], [20]. The integration of green building concepts into housing product design education, through the path of curriculum development, combining theory and practice, and revolutionizing teaching methods, can improve students' knowledge of green building in the process of cultivating technical knowledge and ability to meet the future demand for green housing [21]-[24].

Against the background of global climate change and increasingly severe environmental pollution, green building, as an important direction for the sustainable development of the construction industry, has become the consensus of the international construction community. Green building not only focuses on energy saving and emission reduction of buildings, but also emphasizes the harmonious coexistence with the natural environment and the pursuit of the unity of economic, social and environmental benefits. In recent years, China's government has attached great importance to the development of green building, and introduced a series of policies and regulations to promote green building from concept to practice. However, the promotion and application of green building concepts require the support of a large number of talents with professional knowledge and innovation ability, which poses a new challenge to traditional architectural design education. Traditional housing product design education often focuses on the teaching of theoretical knowledge, and lacks the cultivation of students' practical ability and innovative thinking, which makes it difficult to adapt to the talent needs of green building development. At the same time, the traditional teaching mode with clear disciplinary boundaries also restricts students' ability to comprehensively use multidisciplinary knowledge to solve complex problems. STEAM education, as an emerging education concept, emphasizes the organic integration of science, technology, engineering, art and mathematics, and cultivates students' interdisciplinary thinking and innovation ability through project-based learning and practical experience. The characteristics of this educational model are highly compatible with the requirements of green building concept for talent cultivation, and provide new ideas for the reform of housing product design education.

Based on the above background, this study firstly analyzes the connotation characteristics of STEAM education concept and the design characteristics of green building housing products in depth through literature research, and constructs a green building housing product design teaching mode based on STEAM education concept. Subsequently, a controlled experiment was designed, and two parallel classes were selected as the research objects; the experimental class adopted the newly constructed teaching mode, and the control class adopted the traditional teaching method, and the teaching effect was evaluated from multiple dimensions through three months' teaching practice. Through questionnaire survey, work evaluation and statistical analysis, the study objectively assesses the impact of the new teaching mode on students' learning interest, professionalism and innovation ability, and provides empirical support and practical guidance for the effective integration of green building concepts in housing product design education.

II. Housing product design education based on STEAM education concepts

II. A. STEAM Education Philosophy

II. A. 1) Definition of STEAM Education

Nowadays, STEAM education is a popular research direction in the field of education nowadays, which emphasizes the characteristics of multidisciplinary integration and comprehensive training. Through practice, it cultivates students' training, logic, design, innovation and other necessary skills. It integrates the multidisciplinary fusion of math, technology, science, engineering and art, emphasizing creative thinking, hands-on practical ability and logical thinking and innovation.

II. A. 2) Development of STEAM education

With the shift from STEM to STEAM, the concept of STEAM, which synthesizes and integrates multiple disciplines, is becoming more and more rooted in the field of education [25]. In this context, the science of STEAM education represents the use of scientific knowledge and technology to help people recognize the world through a scientific attitude. Engineering is mainly a means to help people understand the world, mathematics is integrated into various disciplines to provide multidisciplinary learning through scientific computing, and art is a beautiful form of presentation to enrich people's material life.

II. A. 3) Connotation and Characteristics of STEAM Education

After analyzing the literature research related to STEAM education at home and abroad, the main viewpoints are concentrated on the following points:

(1) Connotation:

The teaching of STEAM focuses on the cultivation of innovative talents. On the one hand, it attaches importance to the mastery of basic knowledge and the integration of multidisciplinary and interdisciplinary knowledge. On the other hand, it attaches importance to practical hands-on ability, logical thinking training, cooperation and communication, aiming at cultivating comprehensive technical talents and improving the comprehensive competitiveness of the country.

(2) Characteristics:

STEAM education has features such as interdisciplinary integration, fun, experience, contextualization, cooperation, design, art and technology enhancement.

Interdisciplinary integration mainly emphasizes the integration of different kinds of disciplines and knowledge into a whole in a reasonable way, so as to cultivate students' learning ability and adaptive thinking ability to solve problems through practice. Interest refers to the STEAM education, the interest of the connotation added to the knowledge points learned, to promote the motivation of students to learn efficiently and the development of habits. STEAM education experience is mainly based on the learning process, hands-on experience, practical experience can help students to link theory to practice, in life, the importance of the theoretical knowledge learned through practice to solve practical problems [26]. STEAM education Emphasizes the interconnectedness of the real world and learning, with situational application characteristics. In a certain situation, in order to solve the actual problem, the whole process of mastering the knowledge will be richer and more meaningful. STEAM teaching is not only a teaching method, but also creates the opportunity for learners to self-expression and communication and learning. By solving real-world problems, collaborating and communicating, and helping each other, learners' language organization and social communication skills are strengthened and trained. Problem solving often requires coordination and cooperation, and learners assist each other and motivate each other in the group to find the best way to solve problems, which is also a process of building their own social cognition. Artistry is mainly embodied in the form of beauty, the cultivation of students' aesthetic needs, and the stimulation of the aesthetic sense of creative thinking. Technology as a method and means of education, to better provide students with a comprehensive knowledge of learning, mastery of emerging technologies, and solve practical problems.

II. B.Housing products based on green building concepts

The design of housing products based on green building concepts is mainly based on product hardware systems, software systems and online education platforms. The hardware and software types of green building concept-based housing products are mainly in the form of remote control robots, providing users with programming instruction. The software type of housing products based on the green building concept is mainly in the form of fun and creativity, emphasizing classroom interaction. The network programming education platform mainly provides users with online graphical learning, learning programming knowledge through graphical programming.

II. B. 1) Design characteristics of intelligent housing products based on green building concepts

Housing product design based on green building concepts has a nearly similar match with STEAM educational product design. As a result, the design attributes of STEAM educational product design are mostly dominated in the design attributes of housing products based on the green building concept. The design attributes are the basic guidelines embodied in STEAM educational product design. There are two basic principles in the design of housing products based on the green building concept, which are exploring a characteristic of STEAM education and the fun experience.

II. B. 2) Smart housing products based on green building concepts seek opportunity points

According to the research and analysis of the design characteristics and value features of the intelligent green building concept-based housing products, so as to determine the objectives of the programming products in the design practice, it can be seen that the purpose of the intelligent green building concept-based housing product design is:

(1) Enhance the practical ability of the user group through the operation of intelligent green building concept-based housing products, and learn STEAM knowledge and integrative cultural knowledge in the process of fun learning. (2) Learning educational programming knowledge through intelligent green building concept-based housing products, solving practical problems while innovative thinking can be trained [27].

III. Design of teaching experiments

III. A. Pre-implementation Preparation for Teaching and Learning

(1) Duration and content of teaching implementation

Teaching implementation time: October 2024 to December 2024 Teaching implementation of the main content: first for the students to learn the foundation of housing product design, so that they have a certain understanding of this, and then start teaching practice.

(2) Purpose of teaching implementation

By comparing with the traditional teaching mode, to test the impact of the method based on this paper on students' innovation ability and learning effect.

(3) Selection and analysis of teaching objects

The author selected two parallel classes in a school for controlled experimental teaching, each class has two housing product design classes per week, and the length of each class is 40 minutes. This study was conducted as a comparative study with teaching practices in experimental and control classes with traditional teaching methods and teaching methods based on the methodology of this paper. The subject classes were named as class 1 and class 2, where class 1 was the experimental class and class 2 was the control class. A total of 100 students participated in this experiment, with 50 students in both experimental and control classes.

III. B. Teaching and Learning Implementation Process

(1) Teaching process of the control class

The teaching of the control class is mainly based on the teacher's teaching and practicing, and the students imitate and learn accordingly, and finally design and produce their own works. The teaching content and teachers of the control class are the same as those of the experimental class. Each teaching case in the innovation phase is divided into three lessons. In the first lesson, the teacher organizes and guides the students to review the basic knowledge and learn new knowledge, then introduces the case theme of the course and arranges specific tasks for the students while presenting the relevant cases. In the last two lessons, students complete the related teaching tasks, mainly the design and production of models.

a) Knowledge Review

Teaching activities before the start of the lecture to review the basic commands that may be used in the modeling process to ensure that the students' ideas are really realized, the process of teachers to explain the contents of as comprehensive as possible, to help students carry out the next design.

b) Teachers arrange tasks and display exercises

Teachers according to this lesson teaching case for students to arrange specific learning tasks, and a more complete example of an example of drawing demonstration and demonstration.

c) Students' operation to complete the task

Arrange for students to complete the task according to their own ideas, and finally complete the model design of a work.

(2) Teaching implementation process in the experimental class

Although the theme of each teaching case is different, the instructional methodology is the same, which is based on design thinking and guided by the instructional design model based on the methodology of this paper. Each teaching case in the innovation phase is divided into four class periods, one more than the control class because this model emphasizes student-centeredness and involves a lot of student discussion and reflection. The first two class periods are about the design of the work and the last two are about the production of the prototype.

IV. Analysis of experimental data

IV. A. Analysis of students' interest level during class time

The survey was conducted after the teaching experiment by distributing the “Students' Interest in Class Time Scale”, of which 50 questionnaires were distributed to the experimental class and 50 valid questionnaires were collected. In the control class, 50 questionnaires were distributed and 50 valid questionnaires were collected. The results of the survey are shown in Table 1. The independent samples t-test analysis of the results of the survey of the interest level of the subject class in class is shown in Table 2. The result of Levine's variance chi-square test is: F-value is 23.152, significance is 0.00. Since the significance of the sample variance chi-square test in this study is 0.000 less than 0.05, the variance is not chi-square, so we choose the T-test data with unequal variances, i.e., the second row of data, and the significance of the mean equivalence T-test is 0.000 less than 0.05, and we can assume that the subject classes Classes 1 and 2 have a significant difference, i.e., the experimental class has a significantly higher level of interest in class time than the parallel class. Therefore, the teaching mode of integrating STEM education is favorable to increase the interest level of students.

Table 1: The results of the survey results

Class	Effective questionnaire	Overall interest in class (score 40 points)	Standard deviation	Standard error mean
Laboratory class	50	37.051	3.701	0.436
Cross-reference class	50	33.162	6.125	0.661

Table 2: Independent sample t test of the results of the survey

	Levin variance equivalence test		Average equivalent t test						
	F	significance	t	Freedom degree	Significance (double side)	Mean difference	Standard error difference	The difference is 95% confidence interval	
								Upper limit	Lower limit
Let's say the variance is equal	23.152	0.000	6.206	146.952	0.000	3.982	1.015	4.629	9.001
Let's say that the variance is not equal			6.011	122.842	0.000	3.982	1.011	4.782	9.005

IV. B. Analysis of students' professional core literacy assessment during class time

In this survey, “students' professional core literacy evaluation questions” were distributed after the teaching experiment, and the statistics of the results of the professional core literacy evaluation survey are shown in Table 3. The independent sample t-test analysis of the results of the professional core literacy assessment survey is shown in Table 4. The results of the independent sample t-test show that the Levine's chi-square test result is: F value is 0.082, and the significance is 0.769. The mean equivalence t-test significance is 0.032 less than 0.05, that is, the two classes have a significant difference, the average score of the experimental class is 12.623, and the average score of the control class is 10.509, and the evaluation score of the professional core literacy of the students in the experimental class is significantly higher than that of the parallel class. Therefore, the teaching mode of integrating STEM education is conducive to improving students' professional core literacy.

Table 3: Professional core literacy evaluation survey results

Class	Effective questionnaire	Professional core accomplishment evaluation score (score 20 points)	Standard deviation	Standard error mean
Laboratory class	50	12.623	3.089	0.432
Cross-reference class	50	10.509	3.152	0.449

Table 4: Test analysis of independent sample t of professional core literacy evaluation survey

	Levin variance equivalence test		Average equivalent t test						
	F	significance	t	Freedom degree	Significance (double side)	Mean difference	Standard error difference	The difference is 95% confidence interval	
								Upper limit	Lower limit
Let's say the variance is equal	0.082	0.769	2.116	98.5	0.032	1.326	0.624	0.074	2.566
Let's say that the variance is not equal			2.116	97.16	0.032	1.326	0.624	0.074	2.566

IV. C. Analysis of Students' Innovative Practical Ability

The analysis of students' innovative practice ability adopts the pre and post-test to evaluate students' innovative practice ability, which mainly includes four dimensions: innovative personality, innovative behavior, innovative thinking and innovative results. The statistics of the evaluation results of innovative practice ability of experimental class are shown in Table 5. The independent sample t-test analysis of the evaluation results of innovative practice ability in the experimental class is shown in Table 6. The independent sample t-test results show that in terms of innovative personality, the significance of the variance chi-square test is 0.741 greater than 0.05, and the significance of the mean equivalence t-test is 0.852 greater than 0.05, and we can think that the experimental class pre and post-tests don't have a significant difference in terms of innovative personality. Therefore, we can consider that the teaching mode of integrating STEM education is conducive to improving students' innovative practical ability.

Table 5: The results of the evaluation of the innovation practice are counted

Class		Sample size	Comprehensive evaluation score of innovative practice ability	Standard deviation	Standard error mean
Creative personality	Pre-test	50	11.73	2.078	0.312
	Post-test	50	11.99	2.026	0.308
Innovative behavior	Pre-test	50	7.2	1.788	0.251
	Post-test	50	8.61	1.442	0.215
Creative thinking	Pre-test	50	11	1.719	0.227
	Post-test	50	10.272	1.766	0.278
Innovative results	Pre-test	50	6.5	1.857	0.265
	Post-test	50	8.45	1.36	0.211
Pre-test summation		50	36.43	7.442	1.055
Post-test summation		50	39.322	6.594	1.012

Table 6: Test analysis of independent sample t of experimental class innovation

		Levin variance equivalence test		Average equivalent t test						
		F	Significance	t	Freedom degree	Significance (double side)	Mean difference	Standard error difference	The difference is 95% confidence interval: Upper limit	Lower limit
Creative personality	Let's say the variance is equal	0.122	0.741	-0.222	98	0.852	-0.088	0.425	-0.965	0.802
	Let's say that the variance is not equal			-0.069	97.29	0.852	-0.088	0.425	-0.965	0.802
Innovative behavior	Let's say the variance is equal	2.691	0.106	-3.914	98	0.000	-1.223	0.319	-1.869	-0.576
	Let's say that the variance is not equal			-3.796	92.853	0.000	-1.223	0.319	-1.869	-0.576
Creative thinking	Let's say the variance is equal	0.285	0.591	-0.008	98	0.902	-0.043	0.341	-0.731	0.652
	Let's say that the variance is not equal			-0.141	98.034	0.902	-0.043	0.341	-0.731	0.652
Innovative results	Let's say the variance is equal	11.541	0.001	-6.274	98	0.000	-2	0.326	-2.655	-1.365
	Let's say that the variance is not equal			-6.075	90.122	0.000	-2	0.326	-2.655	-1.365
Integrated level	Let's say the variance is equal	0.559	0.461	-2.422	98	0.016	-3.346	1.389	-6.126	-0.569
	Let's say that the variance is not equal			-2.392	97.291	0.016	-3.346	1.389	-6.128	-0.569

IV. D. Evaluation and analysis of students' course work

In the course practice, the creation of works based on green building concepts is a process in which students participate together; therefore, assessing the effectiveness of the design of the course instructional activities requires special attention to the students' completion of the works in the classroom. Teachers evaluated students' project work in the classroom including work 1, work 2 and work 3. The evaluation criteria are described in the mastery of classroom theoretical knowledge, program design, appearance building effect, programming function realization, problem solving and the degree of group cooperative learning. After each completion of the project works, students are self-evaluation and group mutual evaluation, the teacher statistically analyzes the evaluation results of each group's project works, and the students' classroom project works rating statistics are shown in Table 7. According to the statistical analysis of students' classroom project works, it is shown that: when the content of the teaching subject is the same and the time of completing the subject is the same, the sum of the number of excellent groups and the number of good groups of the three projects completed by the students in the experimental class is larger than that of the control class. For example, in work 1, the number of excellent and good students in the experimental class accounts for 80%, while the number of excellent and good students in the control class accounts for only 40%. In the experimental class, the number of qualified groups and the number of unqualified groups are lower than that of the control class, and in the experimental group, the number of excellent groups increases and the number of unqualified groups decreases. In the control class, the number of qualified groups did not vary much, and the number of unqualified groups decreased. According to the data analysis, the overall condition of the experimental class is better than the control class every time the project work is completed, and it also shows that the experimental class actively participates in the class to a greater extent than the control class in terms of hands-on practical ability and problem solving ability.

Table 7: Student class project score statistics

Class	Project work	Excellence(108-120)		Good(96-107)		Qualify(72-95)		Out of line(0-72)	
		Group number	Proportion (%)	Group numbe r	Proportion (%)	Group numbe r	Proportion (%)	Group numbe r	Proportio n (%)
Laboratory class	Work 1	4	40	4	40	1	10	1	10
Cross-reference class		1	10	3	30	4	40	2	20
Laboratory class	Work 2	3	30	4	40	3	30	0	0
Cross-reference class		1	10	3	30	5	50	1	10
Laboratory class	Work 3	5	50	5	50	0	0	0	0
Cross-reference class		2	20	2	20	5	50	1	10

V. Conclusion

The study demonstrated significant educational effects of a green building housing product design teaching model based on STEAM educational concepts through three months of controlled experimental teaching. The teaching practice verified the superiority of the new model in several key indicators. In terms of learning motivation, the teaching mode integrating STEAM education successfully enhanced students' classroom participation and enthusiasm for learning, and the students in the experimental class improved 1.41 points in the dimension of innovative behavior, from 7.2 points in the pre-test to 8.61 points in the post-test, which indicated that the students' willingness to explore and practice on their own initiative had been effectively strengthened. In terms of professional competence cultivation, the new teaching mode significantly enhanced students' professional core literacy through interdisciplinary knowledge integration and project-based learning, and there was a significant difference between the two classes, proving the effectiveness of the teaching reform. In terms of innovation outcome output, students in the experimental class achieved a significant increase of 1.95 points in the innovation outcome dimension, jumping from 6.5 to 8.45 points, reflecting the significant improvement in students' innovative thinking and practical ability. The assessment of the quality of the work further confirms the effectiveness of the teaching, with the experimental class achieving a 100% excellent and good percentage in the evaluation of work 3, compared to only 40% in the control class, which is a huge difference. These data fully prove that the teaching mode of combining green building concepts with STEAM education can not only effectively improve students' professional skills and innovation ability, but also cultivate their sense of sustainable development and interdisciplinary thinking ability, exploring a practical educational path for the cultivation of green building talents in China.

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