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Research on Interior Renovation Design Strategies and Post-Use Evaluation of Smart Classrooms in Colleges —— Taking Tongji University as an Example

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Abstract: Intelligence has become an important driving force for human beings to increase productivity and improve the quality of life since 21st century. In the field of education, using intelligence to upgrade classrooms has become a future development trend. There are many colleges and universities in China and they mainly rely on intelligent equipment to realize the upgrading of classrooms. However, the matching teaching mode and the overall environment of the teaching space are still neglected, resulting in the failure of fully use of intelligent equipment. This paper studies the design practice of the interior renovation of smart classrooms in Tongji University in Shanghai, using the methods of literature research, field surveys, questionnaires and post-use evaluation. The design strategies of the teaching space are summarized from space layout, interface materials, color design, light and lamp selection, historical style, and combination with intelligent facilities. At the same time, the design team also conducted a survey on the post-use feedback of students in Tongji University. Through the post-use evaluation and analysis of the collected data, it was concluded that the research population are satisfied with the following four aspects: space design (the use of materials and colors, space style and scale, retention and using historical style elements), classroom teaching (efficient and comfortable learning atmosphere), physical environment (comfortable light and acoustic environment), intelligent equipment (advanced facilities, easy to find, and conducive to teaching activities). This research can provide reference for future combination with intelligence and teaching space environment design.

Keywords: Interior Design, Smart Classroom, Interior Renovation, Educational Environment, Post-Use Evaluation

1. Introduction

The classroom environment design and teaching effect are closely related to the teaching mode. At present, there are mainly two teaching modes of "teacher-centered" and "learner-centered", corresponding to the theory of "objectivism" and "constructivism" respectively [1]. Most of the early teaching models originated from the theory of objectivism, but with the development of the times, the traditional teacher-centered classroom is increasingly transformed into a student-centered classroom, which has become a new trend in education models. The opinion that "a learning environment that conforms to constructivist

theory may be more effective" has also begun to be recognized more interactive by modern academic study [2]. At the same time, constructivist learning theory is more suitable for openness in the higher education environment [3]. Therefore, smart classrooms are compatible with the new teaching model (constructivist learning).

The smart classroom is the product of the deep integration of technology and education. Different from common teaching space and forms, in the context of the intelligent age, the improvement of the teaching space environment should match the smart equipment and facilities. How to design the learning environment is the core issue of improving the teaching space. In the field of

architecture, recently it has mainly devoted itself to research in the following three aspects: improving the physical environment of the classroom (such as: sound, light, heat environment, air quality, etc.); introducing research results in ergonomics, environmental psychology and other disciplines to design teaching space layout; cooperating with engineers to improve the quality of learning environment through intelligent equipment [4]. There are some successful cases in the above three aspects, but there is also room for further improvement. Therefore, it is very necessary to adapt the teaching space design to intelligent environment. The purpose of this paper is to explore the design strategies and a complete verification process of college students in the physical environment through the smart classroom renovation projects in Tongji University, Shanghai, China.

2. Methods

The smart classroom is adapted to the new teaching mode (constructivist learning) as the future trend is learner-centered. This research takes "constructivist learning" as the basis of smart classroom design, adopts the methods of literature research and case analysis, in order to expand the source of theoretical basis and consolidate the research foundation of the project. Using field research, combined with engineering practice projects, to explore design principles and strategies is the following step. After the completion of the design project, questionnaires are used to collect data. Based on post-use evaluation theory, using relevant statistical analysis tools to verify and analyze the design practice results of the interior renovation of smart classrooms in universities is the last step.

2.1. Literature Review of Smart Classrooms

The research and exploration of smart classroom abroad is earlier than that in China, which can be traced back to the concept of "smart classroom" put forward by Ronald Rescigno in a speech in 1988 [5]. Nevertheless, the full spread of smart classroom research is still carried out with the development of technology, cloud computing technology and Internet of Things technology under the background of smart earth [6]. Foreign universities have also begun to explore the project practice of smart classrooms very early. For example, the TEAL (Technology Enabled Active Learning) program of the Massachusetts Institute of Technology in the United States is equipped with more advanced teaching technology products than traditional classrooms, providing students with a highly collaborative, hands-on and interactive learning environment [7]. The TILE (Transform, Interact, Learn, Engage) program classroom at the University of Iowa is designed to support active learning instructional strategies such as collaborative learning, peer instruction and activities that benefit from networked computer access [8].

In order to further understand the research status of smart classrooms, the research team selected two databases,

Springer and IEEE, as research data sources, searched the literature of the past ten years (2011-2020) with "smart classroom" as the keyword. 84 articles are obtained after screening. It is found that: the number of papers published on smart classroom research is generally on the rise (Figure 1), and the number of papers published before 2016 is relatively small, with an average of less than 4 papers per year; after 2016, the number of publications has increased, and the average annual publication volume has reached 13.

In the existing literature related to the practical cases of smart classrooms in China, most of them focus on the design and application of advanced equipment and systems, as well as the innovation of teaching models. For example: learning space, information technology and teaching methods, among which learning space includes advanced physical environment system and seating layout [9]; Lv Liansheng et al. took China University of Mining and Technology as an example from the electronic blackboard writing function, multi-screen display system, intelligent interactive platform; Smart classroom environment rather on traditional teaching methods includes four aspects: movable tables and chairs, and touch all-in-one machines [10]; Zhang Tianrong summarised five aspects of smart classrooms in Zhejiang Agriculture and Forestry University [11]; He Zhankui took the smart classrooms of Central China Normal University as an example and proposed that "the integration of physical space, resource space, and interactive space is Trinity construction mode" [12].

In order to further understand the research status of smart classrooms in China, the research group used "smart classroom" as the keyword to search the literature of the past ten years (2011-2020) in the CNKI database, and a total of 795 Chinese literature were obtained. Analyzing the number of papers published each year from 2011 to 2020, it can be found that the number of papers published on smart classroom research in China has shown an obvious upward trend, and the growth rate has been significant (Figure 2). From 2011 to 2015, the average number of papers published was only 11.2 per year, and since 2016, the number of published papers has increased sharply, reaching an average of 147.8 per year, with the highest being 244 per year in 2019 and falling to 178 per year in 2010.
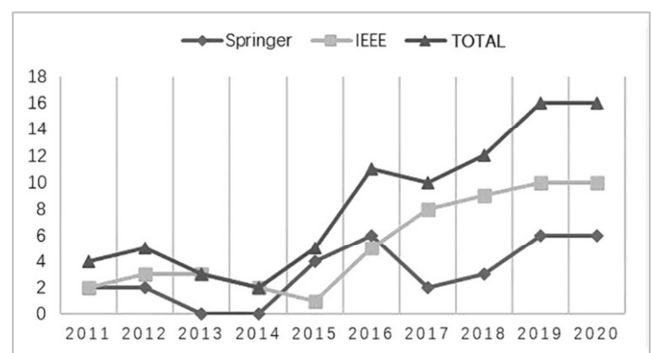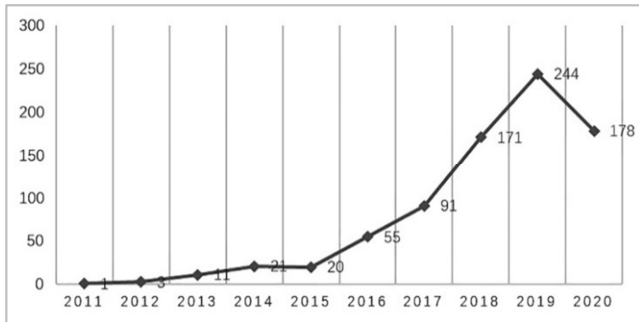

Figure 1. Time and Amount of Papers Published on Smart Classrooms in Springer & IEEE (2011-2020).

Figure 2. *Time and Amount of Papers Published in Smart Classrooms in CNKI database (2011-2020).*

2.2. Field Observation

At present, there are some problems in the teaching space of the Siping Campus of Tongji University: it is difficult to meet the requirements of the intelligent equipments; the participation of students in teaching activities is not high; the teaching space lacks humanized considerations; the teaching facilities and environment are relatively old. The former view of the classroom before renovation is shown in the figure 3. During the design process, combined with literature review and theoretical thinking, it is hoped to improve the learning effect of learners. Focusing on the performance of the smart classroom learning environment and promote the development of teaching space in colleges and universities in a more scientific and humanized direction. The floor plan of the classroom after renovation is shown in figure 4, and photos of the classroom are shown in figures 5-6. The interior views of the lecture hall where the red tables and chairs are kept to maintain the historical atmosphere are shown in figures 7-8. Figures 9-10 show the interior view of the public space and teachers' lounge in the teaching building.
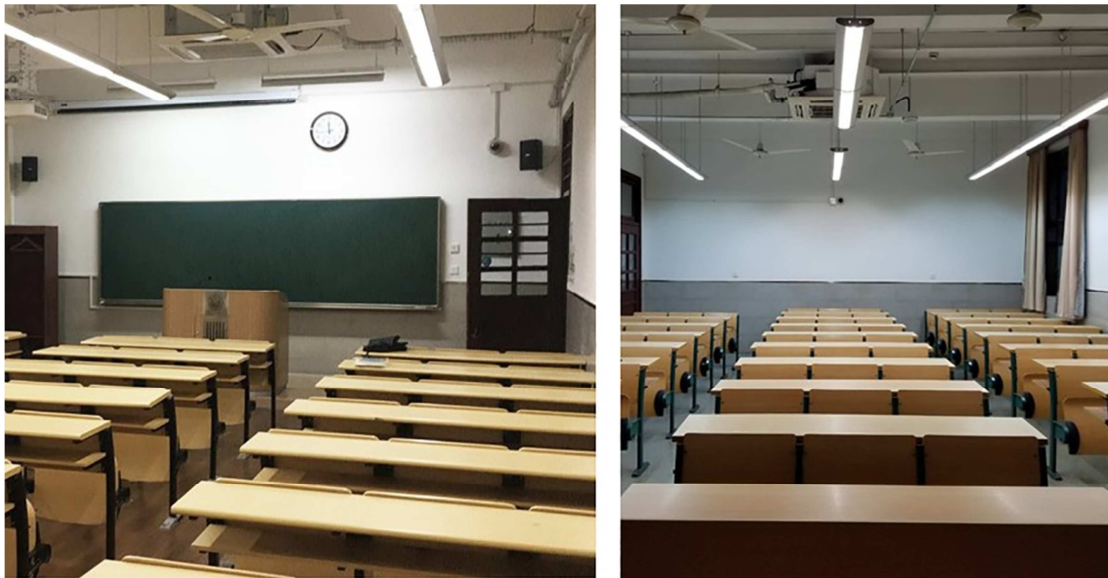
Figure 3. *Former photos before renovation of the classroom.*
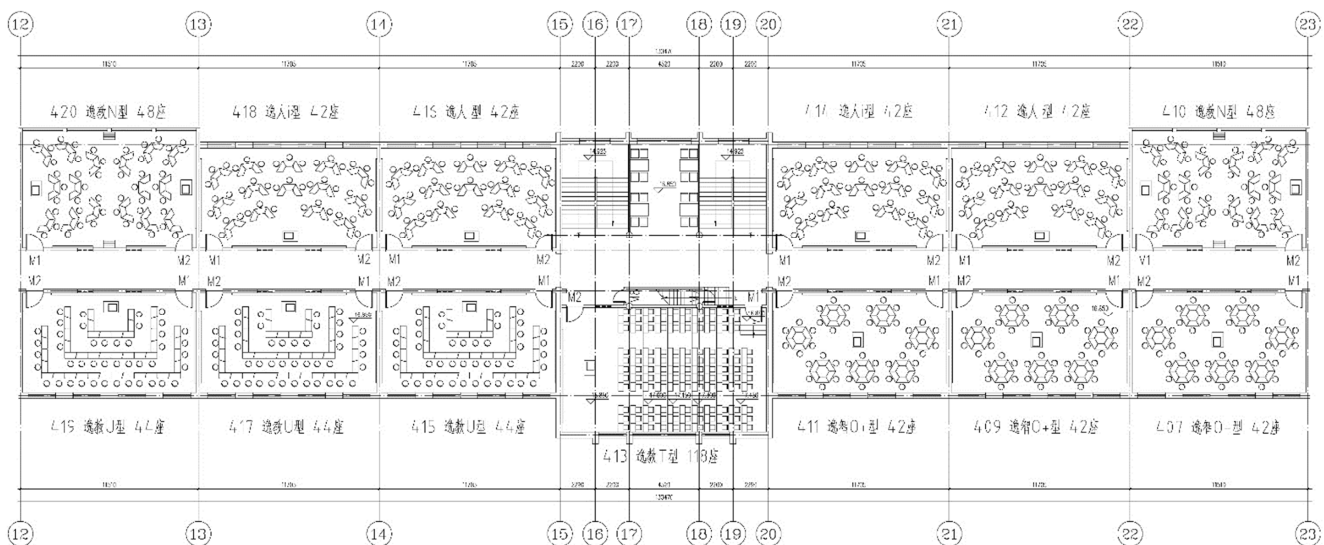
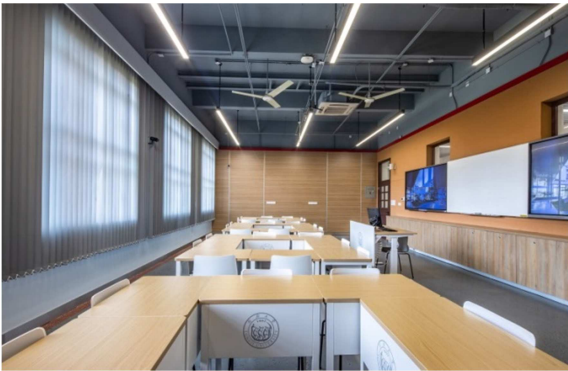**Figure 4.** *Floor plan after renovation of the classroom.*

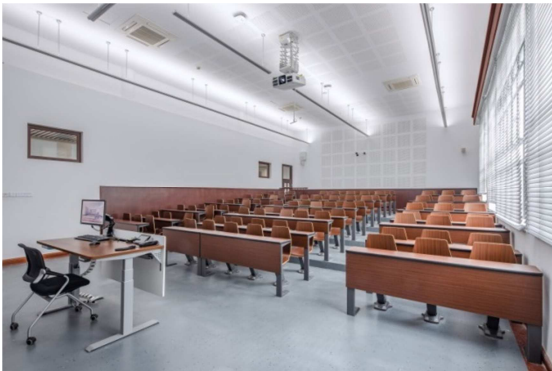*Figure 5.* *Photo after renovation of the classroom.*

Figure 8. *Photo after renovation of the lecture hall.*
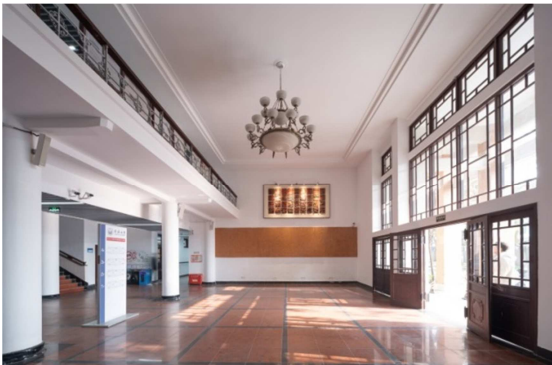

Figure 6. *Photo after renovation of the classroom.*
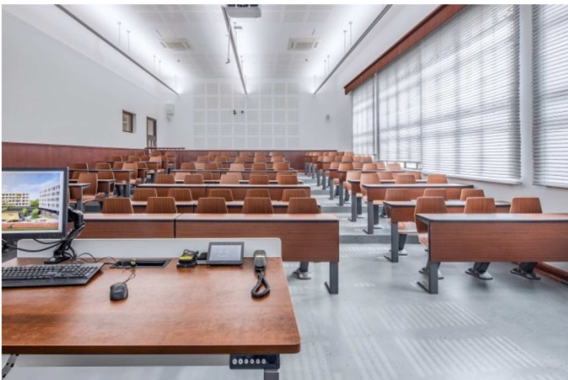

Figure 9. *Photo after renovation of the public space.*

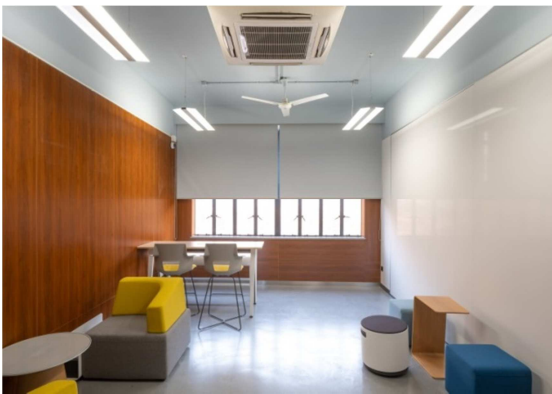*Figure 7.* *Photo after renovation of the lecture hall.*

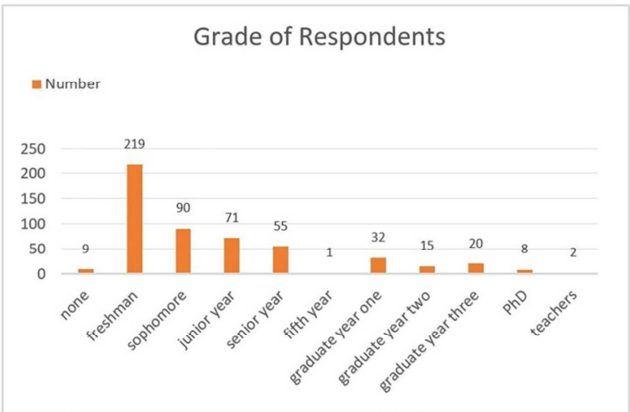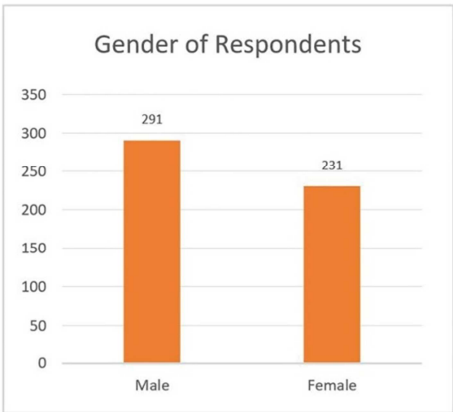*Figure 10.* *Photo After Renovation of the Teachers' Lounge.*

Figure 11. *Statistical Information About Respondents.*

2.3. Questionnaire

Post-assessment questionnaires were distributed after the renovation in fall 2020 semester. Judging from the feedback received, the students were generally satisfied with the transformation effect. A total of 525 questionnaires were distributed, including undergraduates, graduate students, doctoral students and teachers, and 522 valid questionnaires were recovered. The statistical results are credible. The gender and grade distribution of the respondents are shown in figure 11.

3. Results

According to the literature review and analysis of smart classrooms in China and abroad, we can see that: The current literature research on smart classrooms is mainly concentrated on the fields of computer technology, educational theory and educational management. There are few related studies starting from the perspective of physical space design; In the practical case analysis of smart classrooms, most cases rely on advanced intelligent equipment and systems to fulfill the functions of smart classrooms, but ignoring the role of physical space design; Most of the current literature focuses on a single element (such as: color, sound, light, etc.), lack of in-depth systematic research.

The design strategies include the following aspects: space layout, interface materials, color design, lighting and fixture selection, historical features, integration with intelligent facilities, and creation of a healthy and safe environment, see Table 1. Satisfaction feedbacks from users include the following four aspects: space design (the use of materials and colors, space style and scale, retention and using historical style elements), classroom teaching (efficient and comfortable learning atmosphere), physical environment (comfortable light and acoustic environment), and smart devices (advanced facilities, easy to find, and conducive to teaching activities), see figure 12.

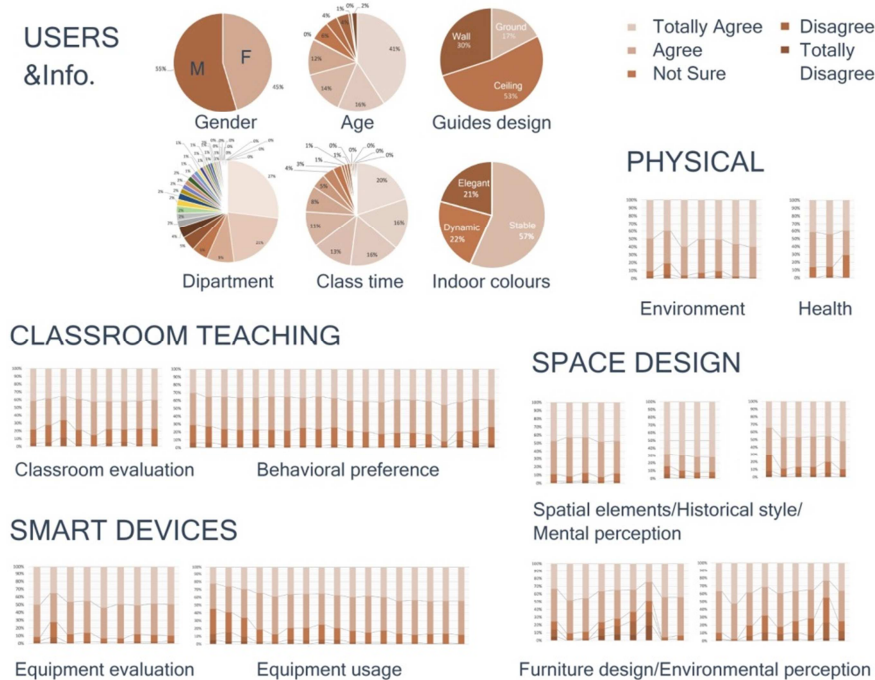***Table 1.** Design Strategies.*

***Figure 12.** Satisfaction Feedbacks About Smart Classroom.*

4. Discussion

Most of the early teaching models originated from the theory of objectivism, the traditional teacher-centered classroom is increasingly transformed into a student-centered classroom, which has become a new trend in education models [13]. It can be seen from the feedback that users are highly satisfied with space design, teaching, physical environment, smart equipment and other aspects. In the traditional classroom space, the mode in which the teacher lectures on the podium and the students sit in rows to listen to the lectures is not conducive to the communication between teachers and students [14]. After the transformation of smart classrooms, freely movable tables and chairs, movable desks, and flexible partitions can bring about a free and changeable classroom space, and can bring different teaching modes such as listening, discussing, and giving speeches. The selection of interior decoration materials, furniture, lamps, etc. is based on texture, acousto-optic effects, campus signs, combined with smart devices, such as electric curtains that can adjust the light intensity, ceiling lights that create a diffuse light environment, and original materials for corresponding historic buildings, etc. [15]. The intelligent creation of smart classrooms is also reflected in the integration with technical equipment. For example, the screen and the blackboard are combined to increase the integrity; the hosts of various equipment are installed in the cabinet to ensure unity, and at the same time, it can be easily opened, debugged, maintained and replaced.

The number of colleges and universities in China is huge, and the number of new or renovated classrooms is increasing every year. The results of this research on the design and renovation of the smart classroom environment can be applied to the renovation (or new) design of the interior space of smart classrooms in various universities, and can also be extended to primary and secondary school.

5. Conclusion

Firstly, the transformation of the space mode of the smart classroom should be adapted to the teaching mode, and using intelligent technology to deeply integrate the new technology with the teaching requirements;

Secondly, the interior design of classrooms should be more humanized, and innovative strategies should be adopted to improve the quality of the classroom environment;

Thirdly, we need to focus on the civilized culture in the classroom. The design pays attention to the protection and restoration of historical features and the special connotation of modern architecture;

Fourthly, the interior design should be carried out simultaneously with the discussion and ordering of various equipment, and the manufacturing price should be strictly controlled, for the goals to be practical, economical and beautiful.

It is hoped that through continuous research, more experience will be accumulated for future teaching space transformation, and more references will be provided, so as to promote the development of teaching space design in universities towards a more scientific, reasonable and humanized direction.

Acknowledgements

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