Face-to-face Teaching in the Flipped Classroom Supported by Visualization Tools – Taking the course of "Architectural Design of Housing" as an Example

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Abstract—Multimedia-based information technology, especially the flipped classroom using micro video technology, has gradually changed the traditional classroom teaching and become a new teaching method to improve teaching quality. The "five-ones" teaching model combines the theory of flipped learning, micro-video theory and learning target cognitive hierarchy. Visualization tools can create real-time, evidence-based, full-participating classrooms, generating a positive effect on classroom teaching reform. Therefore, with the focus on the course of Architectural Design of Housing, a number of students of X-university majoring in civil construction were involved
in an experiment of face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model. The results show that face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model has a significant effect on improving the quality of course teaching, but it also puts higher requirements on the teaching environment, teachers' ability and students' self-control.

Keywords—Visualization tools, "five-ones" teaching model, Architectural Design of Housing

1 Introduction

In the flipped classroom, face-to-face teaching is the main way of teaching, aiming to encourage teachers to give personalized guidance in the classroom according to the teaching situation through various activities, such as self-inquiry, learning test, group discussion, presentation communication, homework practice, etc., foster a positive and open learning culture, promote students' internalization of knowledge structure, and enhance students' learning ability; hence, it is quite different from traditional teaching which focus on knowledge transmission [1]. Face-to-face teaching requires the construction of a real-time, evidence-based, full-participating classroom learning model centered on students. In the classroom, various methods are adopted to stimulate the initiative and participation of students and make full use of the flipped classroom. Visualization tools provide a technical foundation for the application and implementation of the flipped classroom, allowing students to visualize selections,

assessments, and processes in the flipped classroom [2]. In terms of the application value of visualization tools, discussion is mainly concentrated on classroom response systems or the voter Clicker [3]. Currently, the use of Clicker is generally welcomed by teachers and students. For instance, Hauswirth & Adamoli [4] pointed out that "Clicker will be the most promising teaching technology in the next 20 years". On the one hand, Clicker enables all students to participate and make their own voices, which can effectively enhance students' participation in learning and enthusiasm for learning. According to Landrum [5], among 25 teaching studies on the use of Clicker, 23 studies showed that using Clicker in class allows students to have a higher level of attention. On the other hand, Clicker enables teachers to understand students' learning in real time, and to provide timely feedback, personalized guidance or instructional adjustments. Hoekstra et al. [6] presented mixed-methods and data to examine the use of Clicker in two sociology courses (2007 to 2013). Survey, observation, and interview data indicate that student response systems might contribute to the building of empathy for diverse perspectives and the enhancement of class discussions by supporting participation and engagement, but proper implementation is required.

As the core of basic education reform, classroom teaching is directly related to the quality of student training [7]. The reform of classroom teaching stems from two angles. One is the "top-down" model led by theoretical innovation and promoted by individual experiments. The other is the "bottom-up" model which starts from classroom teaching practice and emphasizes continuous exploration, accumulation and improvement to form a new practice paradigm and theory [8]. In recent years, the latter model, dominated by the flipped classroom, has been widely practiced abroad. The attempt to localize flipped learning in China is also constantly updated and improved. However, in the classroom teaching of basic education in China, on the one hand, the basic paradigm of "in-class lecture + after-class exercise" remains the same. On the other hand, despite the attempt to use the flipped classroom, there are still many problems in the true transformation to student-centered classroom, resulting in the "distortion" of most classroom teaching reforms [9]. O'Flaherty & Phillips [10] believed that the flipped classroom is only the first stage of classroom teaching reform, and the real realization of student-centered classroom requires the second stage, namely flipped learning. The three basic elements of flipped learning are course content, curiosity and teacher-student relationship. Herreid & Schiller [11] suggested that flipped learning is a further extension and development of the flipped classroom. Traditional learning is a concentrated learning process of knowledge transfer; after students are separated, it is the process of internalization or consolidation of knowledge. Flipped learning is the opposite. When students are separated, they conduct individualized learning (knowledge acquisition) through the network and other channels. When they are together, they share, communicate, practice, and create to deepen, consolidate, and innovate what they have learned. The flipped classroom emphasizes shifting learning to pre-class self-study via videos, while flipped learning pays more attention to the flipping that occurs in the classroom and establishes an environment suitable for deep learning in classroom teaching.

The classroom teaching of the major architecture in China still uses the basic paradigm of "in-class lecture + after-class exercise" which is centered on teachers.

For students, such a paradigm has problems such as low participation, passive learning, and superficial learning. As far as teachers are concerned, it is difficult to teach students in accordance with their aptitude, use classroom time efficiently, or guide students to deepen and extend their learning; meanwhile, there is no environment for students to learn actively [12]. The teaching model of the course still belongs to the basic paradigm of "in-class lecture + after-class exercise". The specific forms are "lecture before exercise" and "lecture while exercise". As for the former, theory and practice are disjointed. The latter makes it difficult for students to build a complete knowledge system. Neither of them is conducive to cultivating students' ability and creativity of using technology to solve practical problems [13]. In addition, the major architecture has realistic problems such as fast content update, strong operability, and less class time. The "five-ones" teaching model, derived from the flipped classroom, is the mainstream model which combines the theory of flipped learning and learning target cognitive hierarchy to construct the teaching process of "pre-class study-in-class exercise-in-class test-in-class completion of projects", providing a theoretical basis for the flipped classroom. With the support from the theory of flipped learning and micro video, the "five-ones" teaching model of "one knowledge point, one explaining micro video, one interactive exercise micro video, one interactive test micro video and one project realization micro video" was constructed and practiced according to the background and trend of classroom teaching reform and the teaching characteristics of the course, reaching the goal of the intersection of the three elements of flipped learning and the student-centered purpose, to solve a series of problems in the teaching of the course.

According to the problems above, this study is innovative in the construction and implementation of the "five-ones" teaching model with the support from the theory of flipped learning and micro video in the teaching practice of the major architecture in university, according to the background and trend of classroom teaching reform and the teaching characteristics of the course. At the same time, different visualization tools were used to explore the face-to-face teaching model face-to-face in the flipped classroom brought by new ideas and new technologies, providing reference for related research.

2 Visualization Tools

2.1 Types and classroom applications of visualization tools

Visualization tools are information technology tools that help people quickly understand information in the simplest and most straightforward way by conveying information through intuitive graphics, images, and so on [14]. In traditional classroom teaching, visualization tools are generally used to display teaching contents, cognitive patterns and thinking processes, mainly presenting knowledge to enhance students' learning cognition. With the development of information technology, the functions of visualization tools are constantly developing, from the single representation of information to supporting classroom management, teacher-

student interaction, and teaching evaluation [3]. The types of existing visualization tools and their applications in the classroom are shown in Table 1.

Table 1. Types and classroom applications of visualization tools

Type	Classroom application	Common tools	Application conditions
Visualization of learning assessment	Use classroom response tools or voters to instantly understand students' learning	Voter Clicker	All students are additionally equipped with a voter + network multimedia classroom
		Classroom response tool Socrative	Smartphone with corresponding APP + multimedia classroom (Internet connection available)
		Wenjuanxing	Smartphone with corresponding APP + multimedia classroom (Internet connection available)
Visualization of learning process	Use learning process record tools to present student's discussion and learning process in real time	Sticky note	Sticky note + display board + pen
		Electronic sticky note PadLet	Smartphone + multimedia classroom (Internet connection available)
		Time manager Rescue Time	Computer Room (Internet connection available)
Visualization of learning choice	Use tools such as random grouping and extraction to increase the fairness and transparency of learning choices	Random grouping tool Excel	Multimedia classroom
		Random extraction tool ClassDojo	Multimedia classroom (Internet connection available)

2.2 Features of face-to-face teaching in the flipped classroom supported by visualization tools

Visualization tools create a real-time site-specific classroom through instant assessment: A real-time site-specific classroom refers to a classroom in which real-time site-specific connections are built between teachers, students, and knowledge acquisition. In the traditional teaching model, teachers can neither immediately understand students' learning situation nor respond accordingly. In the classroom supported by visualization tools, teachers can use visualization tools to assess students on the site, and immediately get and display the results of the assessment. Students can know their progress in real time, while teachers can control classroom teaching in real time. Students can also use visualization tools to explore independently and determine the discussion topic in the process of discussion, and present the discussion to teachers in a visual way, so that teachers can perceive students' discussion direction instantly.

Visualization tools create an evidence-based classroom through process recording: Using information technology, visualization tools can automatically and quickly record and store students' entire classroom learning process, including when students log in, what applications are used, how long they have studied, students' thoughts and opinions in the classroom, students' answers, etc., providing a basis for teachers to guide, manage, control and evaluate students' learning process and learning progress and for students to understand and reflect on their learning situation, so as to create an evidence-based classroom that highlights speaking with evidence.

Visualization tools create a full-participating classroom through random selection: In traditional classroom teaching, teachers often choose students who answer questions or share opinions according to their own considerations or preferences. In the classroom, only a few students can participate in teaching activities. Visualization tools import the names of all students into the computer in advance and then select them in a random manner in the classroom. Since human factors are excluded, the classroom is more objective and fair, and all students have equal opportunities to participate in the class, creating a full-participating classroom. Due to the random selection of students to answer questions, each student has the possibility of being selected, so that they pay more attention and listen carefully in the classroom; random grouping will prevent students from teaming up with those they are familiar with; otherwise, most of the students in a team are at the same level and cannot improve the discussion result.

3 The "Five-ones" Teaching Model

3.1 The "five-ones" teaching model

"Five-ones" refers to one knowledge point, one explaining micro video, one interactive exercise micro video, one interactive test micro video and one project realization micro video. Except one knowledge point which is an activity of teachers, other "four ones" are two-way activities of teachers and students. The "five-ones" teaching model is shown in Figure 1.

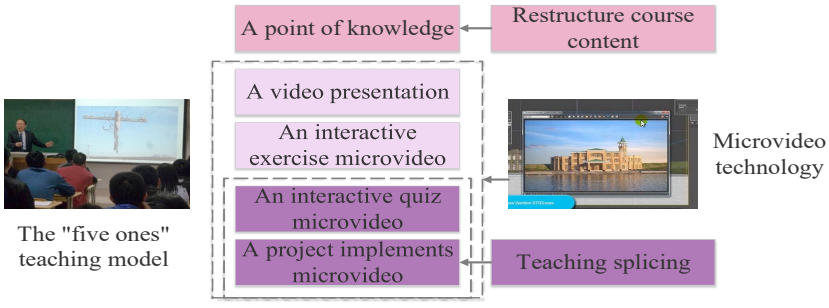

Fig. 1. "Five-ones" teaching model

3.2 Connotation of the "five-ones" teaching model

The "five-ones" teaching model combines the theory of flipped learning, micro-video theory and teaching target cognitive hierarchy. The model is student-centered, with the teaching process as the main line, taking "pre-class study, in-class exercise, in-class test and in-class completion of projects as the teaching method. Obviously, it is different from the traditional theory + experiment teaching model. In particular, the division of teaching target cognitive hierarchy is the key to the teaching model, as shown in Figure 2.

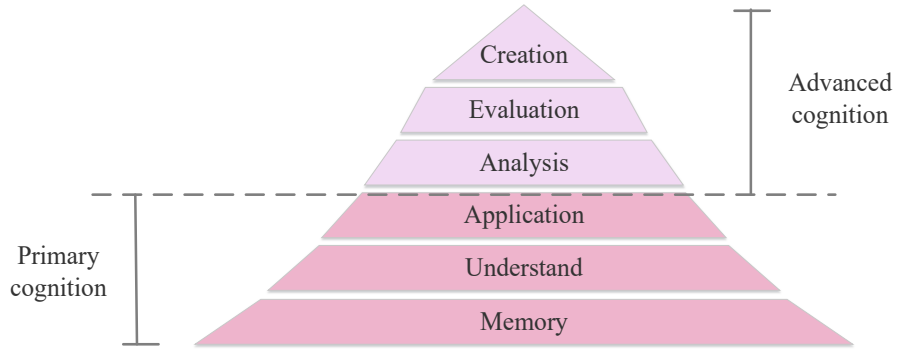

Fig. 2. Division of teaching target cognitive hierarchy

3.3 Procedure of the "five-ones" teaching model

One knowledge point means that the teacher designs the teaching content according to the teaching material, and converts the textbook content into multiple knowledge points of different modules; one explaining micro video indicates that students watch before class the micro video produced by the teacher according to the specific knowledge point; one interactive exercise micro video means that the teacher produces an interactive exercise micro video of actual operation according to the specific knowledge point, so that students can watch and master the operation process in the classroom; one interactive test micro video is the test video produced by the teacher after the teaching of a certain teaching module is completed, for students to operate and the teacher to evaluate; one project realization micro video is the micro video of a comprehensive project made by the teacher through combining multiple knowledge points after all the teaching content is taught. Students watch and learn the design of the project in the classroom. The procedure of the "five-ones" teaching model is shown in Figure 3.

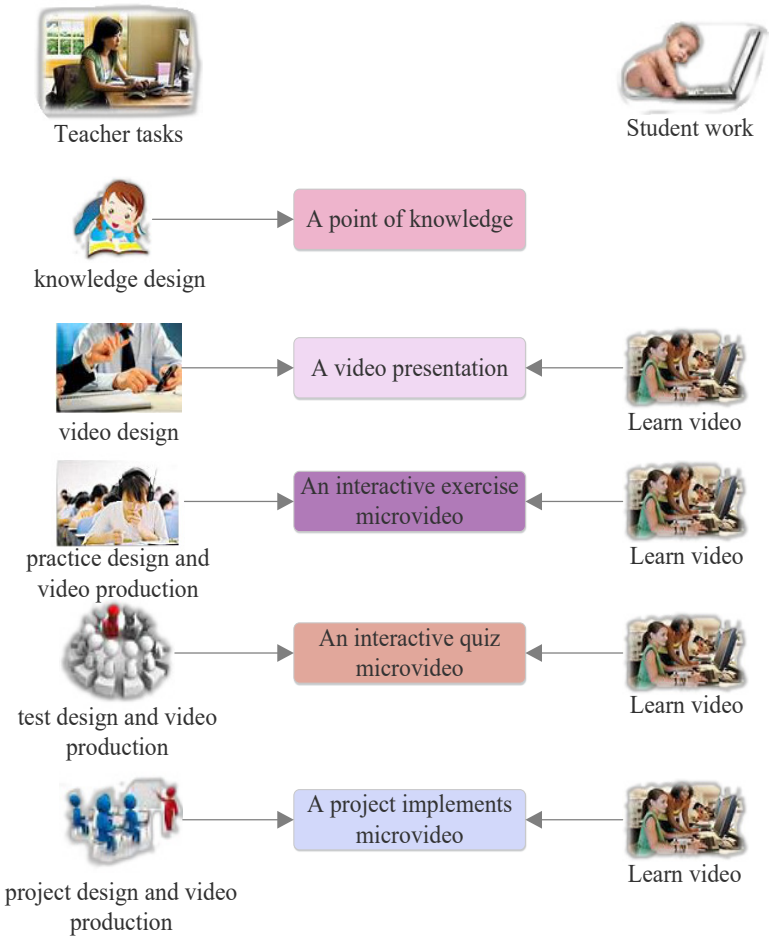

Fig. 3. Procedure of the "five-ones" teaching model

4 Face-to-Face teaching practice in the Flipped Classroom supported by Visualization Tools

4.1 Reconstruction of the course of Architectural Design of Housing

The "five-ones" teaching model was combined with the support from visualization tools to design the teaching of the course of Architectural Design of Housing, and rebuild the content of the course. The content can be constructed as a theoretical module and an operational module. Then, the knowledge points were reconstructed according to the modules. The content reconstruction is shown in Figure 4, and the knowledge point reconstruction is shown in Figure 5.

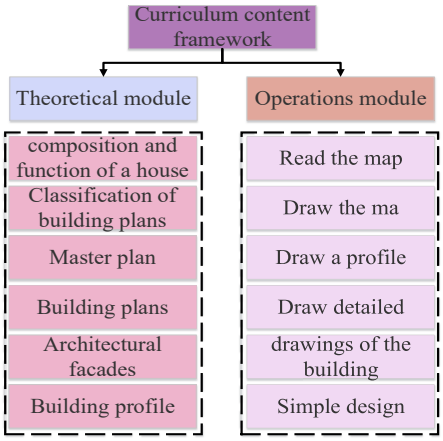

Fig. 4. Content framework of the course of Architectural Design of Housing

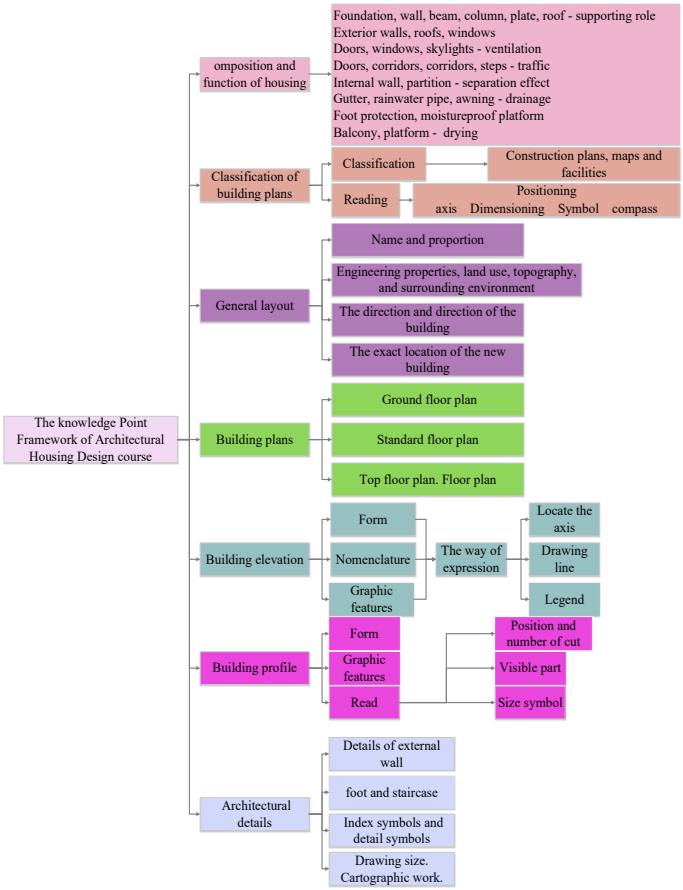

Fig. 5. Knowledge Point Framework the course of Architectural Design of Housing

4.2 Implementation preparation of face-to-face teaching

Forum on the flipped classroom for Architectural Design of Housing: According to the course content of Architectural Design of Housing, the interaction between teachers and students was used as the starting point to introduce the influence of the development and changes of the flipped classroom on classroom teaching, and discuss the factors affecting the flipped classroom teaching, guiding students to pay attention to changes brought by the flipped classroom in teachers' construction, students' self-learning ability, construction of micro-lecture resources, construction of concepts, etc. In this way, students could first have a full understanding of the flipped classroom, laying a cognitive foundation for the follow-up use of face-to-face teaching in the flipped classroom for the teaching of Architectural Design of Housing.

Pre-class self-study of MOOC lessons: According to the content of Architectural Design of Housing, some micro-videos related to the course was selected on the MOOC platform of universities and colleges, including "compositions and functions of housing", "classification of architectural drawings", and "reading of housing construction drawings", "housing general layout and reading", "housing elevation and reading", "housing section and reading", "housing design", etc., enabling students to first carry out online self-study and guiding them to realize the importance of network literacy in the process of learning.

4.3 Implementation process of face-to-face teaching

Description of teaching setting: Before starting the class, the teacher should explain relevant arrangements of face-to-face teaching in the flipped classroom supported by visualization tools for Architectural Design of Housing and the content that needs attention, as shown in Table 2 below.

Table 2. Arrangements of face-to-face teaching in the flipped classroom for Architectural Design of Housing

Teaching link	Tool	Time	Note
MOOC learning test & evaluation	Wenjuanxing	20 minutes	No
MOOC learning summary	Wenjuanxing statistics report + ppt	10 minutes	No
Group discussion	Wenjuanxng +random grouping+ sticky note	20 minutes	Students are randomly grouped; head and team members are not distinguished in the group; the actual topic is decided by vote
Presentation of group discussion results & teacher comments	ClassDojo random extraction	35 minutes	No
Survey on learning experience	Wenjuanxing	5 minutes	No

Description of teaching links

MOOC learning test and evaluation: The teacher designs the MOOC learning test questionnaire for Architectural Design of Housing on Wenjuanxing. The content of the questionnaire should include students' basic information, pre-class learning situation and online MOOC video learning situation. Afterwards, the link address is sent to students through WeChat or QQ. Students can answer questions directly on their smartphones. After students submit their answers, the teacher directly obtains student's answers on the Wenjuanxing management platform, conducts statistical analysis, and then combines the MOOC video learning content to explain and comment on students' answers.

MOOC learning summary: Starting from network literacy, the teacher combines the MOOC course teaching content, guides students how to use the MOOC platform for better independent learning, and leads students to understand what network literacy is, how to cultivate network literacy, the importance of network literacy and so on.

Group discussion: The teacher combines the content of Architectural Design of Housing and gives some relevant discussion topics. Then, students vote to select the discussion topic, engage in discussion of the topic and start from the problem, aiming to find the problem, analyze the problem and solve the problem. Students are randomly grouped by Excel and use sticky notes in discussion.

Presentation of group discussion results and teacher comments: The teacher numbers each group, and then use ClassDojo to select randomly. The selected students present the results of their group's discussion. Afterwards, the teacher comments on the results of each group's discussion.

Survey on learning experience: Wenjuanxing is still used to conduct a survey on students' learning experience mainly to examine students' satisfaction with, as well as advantages and disadvantages of the teaching of Architectural Design of Housing with this model.

Description of teaching environment: The teaching software and hardware used in this teaching include multimedia classroom, computer, projector, internet, smart phone, Wenjuanxing, ClassDojo, Excel, sticky note and other visualization tools.

4.4 Teaching effect

In this study, year-two students of two classes majoring in civil construction at X-university were selected for the teaching experiment. They were divided into the experiment class and the control class, with 40 members in the same class, and taught by the same teacher. Their previous scores in the course are similar. The experiment class adopted face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model. The control class still used the previous teaching model. A one-semester teaching experiment was conducted from February 2018 to July 2018. After the experiment, the scores in the course of Architectural Design of Housing were compared between the experiment class and the control class and the satisfaction of the experiment class with the teaching model was investigated, to analyze the influence of face-to-face teaching in the flipped

classroom supported by visualization tools under the "five-ones" teaching model on the course of Architectural Design of Housing.

Satisfaction of the experiment class with face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model: Wenjuanxing was taken for the experiment class to investigate the satisfaction of students with face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model. As shown in Table 3, 16 students are very satisfied with the teaching model, accounting for 40.0%; 20 students are relatively satisfied with the teaching model, accounting for 50.0%; 4 students hold a general attitude towards this teaching model, accounting for 10.0%; none of them are not very satisfied or dissatisfied with the teaching model. These figures indicate that face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model is warmly welcomed and strongly supported by students.

Table 3. Satisfaction of the experiment class with face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model

Option	Very satisfied	Relatively satisfied	General	Not very satisfied	Dissatisfied
n	16	20	4	0	0
Ratio (%)	40.0	50.0	10.0	0.0	0.0

Comparison of final scores of the experiment class and the control class in Architectural Design of Housing: After the experiment, the final score of the experiment class and the control class were compared. The results are shown in Table 4 below. 8 students in the experiment class have a score above 90 points, accounting for 20.0%; 16 students have 80-89 points, accounting for 40.0%; 12 students have 70-79 points, accounting for 30.0%; 2 students have 60-69 points, accounting for 5.0%; 2 students have less than 60 points, accounting for 5.0%. 3 students in the control class have more than 90 points, accounting for 7.5%; 7 students have 80-89 points, accounting for 17.5%; 15 students have 70-79 points, accounting for 37.5%; 8 students have 60-69 points, accounting for 20.0%; 7 students have less than 60 points, accounting for 17.5%. The average score of the experiment class is 85.6 points, while the average score of the control class is 77.8 points, meaning that the average score of the experiment class is nearly 8 points higher than that of the control class. Obviously, face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model has a positive effect on the teaching of Architectural Design of Housing.

Table 4. Comparison of final scores of the experiment class and the control class in Architectural Design of Housing

Group	Average score	No. of students in each score segment				
		<60	*60-69*	*70-79*	*80-89*	*≥90*
Experiment class (n=40)	85.6	2(5.0%)	2(5.0%)	12(30.0%)	16(40.0%)	8(20.0%)
Control class (n=40)	77.8	7(17.5%)	8(20.0%)	15(37.5%)	7(17.5%)	3(7.5%)

5 Conclusion

In this study, face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model was applied in the course of Architectural Design of Housing, realizing the following innovations: First, visualization tools were used for face-to-face teaching in the flipped classroom, creating a real-time site-specific evidence-based, full-participating classroom and providing specific and operable teaching activities. Second, the "five-ones" teaching model was adopted to design the course teaching under the teaching structure and theoretical framework of relevant educational thoughts, teaching theories and learning theories. Thirdly, face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model was applied to the teaching of civil construction for the first time. In particular, Architectural Design of Housing has many illustrations, high theoretical and operational requirements, and clear teaching concepts, giving specific direction to the course teaching design. Visualization tools can change the teaching content and activities from imagined to "visible", to enhance the teaching effect of Architectural Design of Housing.

Through the examination of the attitudes of the experiment class and the control class towards the teaching model and the comparison of the final test scores, as well as some related problems, it can be found that students have a better impression of face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model. Most of the students expressed satisfaction with the teaching model (90.0%) and their willingness to study the course of Architectural Design of Housing in this way. Meanwhile, the scores of the experiment class in the course are significantly higher after the experiment, forming a big gap with the control group. In answering the merits of this teaching model, many students indicated that random grouping, random extraction, and intuitive illustrations and videos gave them the most profound impressions and positive feelings. Certainly, some students also said that the teaching model has some problems, such as the unstable network which always led to disconnection or jam, waste of time and negative influence on the learning mood.

Although face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model plays a positive role in the teaching of Architectural Design of Housing, there are still some problems when teaching with the "five-ones" teaching model and visualization tools. It should be noted that teachers need to pay attention to the use of the "five-ones" teaching model to reconstruct the course content, which requires them to spend more time and energy and to have higher teaching literacy. This is the basis of course teaching and needs exceptional attention. When using visualization tools for teaching, teachers are supposed to have strong adaptability in the real-time site-specific classroom, so that they can quickly formulate or change the teaching content and strategy according to students' response, and then conduct targeted teaching. Meanwhile, face-to-face teaching in the flipped classroom also requires teachers to provide comprehensive and complete guidance. The teaching model focuses on interactive communication, which requires teachers to have not only knowledge literacy but management literacy. At the

same time, the knowledge provided is not only the content of classroom teaching, but also covers related knowledge points. Certainly, the teaching model also poses challenges for students. The MOOC self-study model requires very high levels of consciousness among students, and it is necessary to prevent students from stop learning or giving up. Moreover, visualization tools are very demanding on the teaching environment, whether it is hardware or software. Therefore, ensuring the teaching software and hardware environment is also a precondition for the smooth implementation of course teaching. Face-to-face teaching in the flipped classroom supported by visualization tools under the "five-ones" teaching model has a significant effect on course teaching and can provide a good experience for improving course teaching.

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