Research on the Application of C Programming Course Blended Teaching Based on "PBL+FC" Model

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Abstract—In consideration of the problems in the teaching of C programming courses, guided by the common problems that students encounter in the C programming courses, based on analyzing the characteristics of flipped classroom, a teaching and learning model based on 'PBL+FC' are constructed to achieve the better learning levels. The model is an integration of three concepts: (1) transfer knowledge before class; (2) internalize knowledge in class; (3) consolidate and summarize after class. In the study, the implementation of the model is introduced in detail and tested by two flipped classes (experimental class and control class) in School of Big Data, Baoshan university. The experiment results show that the flipped classroom based on 'PBL+FC' makes students leading roles of study, and concluded that the flipped classroom teaching of C Language Programming has a good effect on the improvement of students' grades and quality.

Keywords-flipped classroom; C programming course; blended teaching; problem based learning

1 INTRODUCTION

In recent years, the new information technology represented by the Internet, big data and artificial intelligence is becoming the core force to change classroom teaching. The application of information resources in the teaching of the intelligent era has brought great changes in the classroom environment and teaching methods, and diversified the teaching forms and gradually improved the teaching efficiency [1]. Traditional classroom teaching has been difficult to improve students' interest in learning, which forces teachers to carry out relevant teaching reforms based on students' current situation and improve the attractiveness of the classroom to students. In some cases, students are not able to attend classes due to the impact of COVID-19. Therefore, it is necessary for colleges and universities to improve the deficiencies of offline teaching in order to cope with the course teaching under various conditions. C Programming is a basic course set up by many colleges and universities for science and engineering students in the lower grades [2]. The course is usually the first programming course university students take. The teaching purpose of C programming course is to enable students to master the basic grammar norms and basic programming methods of C programming, and cultivate students' ability to analyze and solve problems with computer thinking as well as their ability and quality of program design, so that lay a good foundation for the subsequent study of data structure and other professional courses.

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Recently, the teaching methods and means are constantly updated, flipped classroom has been widely used by a number of other courses. Therefore, the research mainly studies the online and offline hybrid teaching of C programming based on flipped classroom, and the teaching process is carried out for the network engineering students of Grade 2020 from the College of Big Data of Baoshan University in Yunnan Province. In the study, we propose a new teaching model based on problem-based learning and flipped classroom named "PBL+FC ", which aims to solve the problems caused by the lack of time and classrooms needed to supervise and guide the students in learning the prerequisite knowledge needed for C programming course. In the model, Super Star Learning APP, as a hybrid online and offline intelligent teaching platform, can help teachers and students record the teaching process and generate analytical data to make teachers and students summarize and improve the courses [3]. The Problem-based Learning (PBL) teaching method mainly cultivates students' autonomous learning ability to obtain answers to carry out problem-oriented teaching. The teaching method Flipped Classroom (FC) transforms students' learning time from internalized in class to externalized in advance, and shifts students' learning time before class [4]. In the Flipped Classroom, teachers' major mission are to detect the effects of student learning and help students solve difficulties in the learning process.

The remainder of this paper is organized as follows: the state of the "C Programming " teaching methods are introduced in Section 2. In Section 3, the method for the model are illustrated in detail. The experiment results conducted to evaluate our method are described in Section 4. Finally, the conclusions are presented in Section 5.

2 STATE OF THE “C PROGRAMMING”TEACHING METHODS

The course of C programming involves a great deal of teaching contents, especially the programming grammar rules that students need to master. Students generally think that the content is boring and also difficult to remember. Once students do not master the grammar rules, it will be difficult to follow the remaining three structure programs, groups of numbers and pointers. At the same time, it is difficult to start the practical operation of computer programming, which makes it difficult for students to stimulate their interest and enthusiasm in program learning. In the traditional teaching method, most of teachers prefer the teaching method of writing on the blackboard and classroom dialogue, because it provides advantages such as flexibility, low technology, timely feedback, etc[3]. However, traditional teaching methods can be a hindrance if they are not followed correctly. In addition, if the teacher's classroom control ability is insufficient and the teaching method is used improperly, it may lead to poor teaching results, resulting in students' classroom distraction, boredom, passive learning, neglect and learning stagnation. Under the above circumstances, and teachers will be less enthusiasm for teaching reform.

In recent years, education experts have been exploring new methods and learning techniques for active participation in learning. Instead of simply looking at the textbook and listening to the lecture in class, students are now involved in the entire teaching process designed by the teachers[5]. Sinha et al.[6] proposed a strategy about the learning efficiency of the different age groups is affected by the change in teaching methodology. Measure students' learning performance by exploring how to move from a traditional teaching and learning approach to a hybrid approach. Liu et al. [7] consider the problems in the learning of Java programming

courses, present the flipped classroom teaching and learning model based on analyzing the characteristics of MOOC and flipped classroom. Huang et al. [8] in order to analyse the factors that affect the flipped classroom's learning performance, develop a four-dimension model of the factors affecting FCLP based on the revised community of inquiry (RCOI) framework and tested it in three flipped classrooms in a leading Chinese university. In addition, Dombrowski et al. [9] aimed to analyse and rearrange into a flipped classroom framework. The core knowledge was taught based on the "moodle platform " in predominantly interactive formats, and according to the survey in the e-learning group, the platform was highly accepted and frequently used by nearly 66% of participating students. The above studies explain the relationship between the factors that affect flipped classroom. However, these studies are not enough to conclude the causal relationship between the problem-oriented and pre-class internalization of knowledge in flipped classroom and learning performance.

Our study combines the APP of "super star learning" and social software of QQ and Wechat to construct a conceptual model of influencing factors under the framework of "PBL+FC". Meanwhile, the study hypothesized and studied various factors affecting the learning performance of flipped classroom. Finally, using the cognitive data of learners, the paper makes a comparative analysis of the course scores of C programming before and after the model practice, so as to empirically test the hypothesis.

3 METHOD

3.1 Flipped Classroom Model

Flipped classroom model (FCM) means that the traditional learning process is turned over, so that learners can complete the independent learning of knowledge points and concepts in the extracurricular time, and the classroom becomes the place of interaction between teachers and students. Flipped classroom is mainly used to answer questions, report and discuss, so as to achieve better teaching effect [4]. FCM is a "student-centered" teaching model, which conforms to the constructivism learning theory of "active construction" and "meaningful construction". The FC model is shown in Fig. 1

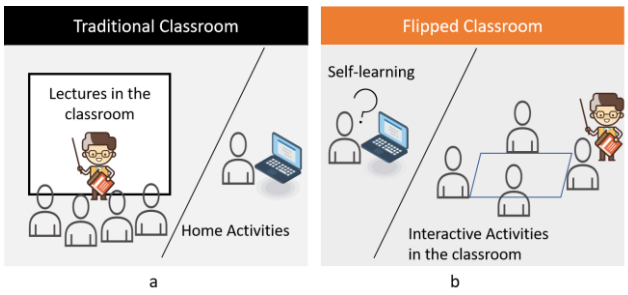

Figure 1 Example of a FC model.

FCM has been the focus of many scholars and teachers, and numerous colleges and universities have carried out teaching practices based on FCM model. In 2011, Jukui Middle School in Chongqing has introduced the "FCM" teaching model. With the help of the "campus cloud"

network platform, they realized that the video teaching of teachers and the partial "flip" of the teaching model[5, 10]. Later, Khan Academy and Fraternity Education Group implemented the "Fraternity Micro-Course Academy", which both reformed and practiced the teaching mode on the basis of the original teaching, and is a beneficial exploration of FCM. Some scholars have also proposed the implementation model of flipped classroom teaching design based on mixed learning, the process design of practice research, the analysis of course content and the overall design of classroom teaching[11]. In the practical application research stage, after the classification of teaching content and the overall design of the classroom, the model and related design are applied to the teaching of "Computer Foundation" course. At present, researches on the application of "flipped classroom" in teaching reform mainly focus on the area of basic education, with relatively few applied researches in higher education courses and few applied examples in university specialized courses. The research on the practical application of flipped classroom in the teaching of "Advanced Language Programming", a basic course for computer majors, deeply integrates information technology with the teaching of college subject courses, and has practical theoretical and practical value in exploring flipped classroom teaching reform suitable for China's national conditions and promoting the application research and development of educational technology.

3.2 Problem Based Learning

Problem based learning (PBL) has been recognized by education experts and teachers, and the implementation of problem oriented teaching is mainly spent on lesson preparation. PBL requires teachers to clarify the following aspects in the teaching plan: teaching objectives, problem background presentation or guidance methods, problem finding angles and ways, what the teacher will teach and what the students will learn by themselves, the form of discussion and research (individual or group), the manifestation of the results of problem solving, etc. The teaching method based on problem-based learning is mainly guided by the problems encountered by students in the learning process after class, such as grammar problems or programming practice problems encountered in the process of self-protection learning of C programming. Instead, students bring the problems into class and gets answers from the teacher or through group discussion, so as to cultivate students' autonomous learning ability and improve the effectiveness of learning.

3.3 What is “PBL+FC” Learning Model

The teaching platform of Super Star Learning is simple, easy to learn, and rich in functions, which can enable some elderly teachers and students to quickly pick up and master. The platform has the function of periodic announcement, which can help teachers timely release class news to students, push preview courseware, videos, exercises and other materials. At the end of the course, the platform will display the comprehensive analysis data of teaching, help students find their weak points in knowledge, urge students to strengthen learning in a certain sense, and help teachers timely summarize the course and adjust the teaching content. Flipped classroom requires students to learn knowledge before class, apply what they have learned in class, and describe the problems or difficulties encountered in learning, so that teachers can answer the questions in class and supplement the knowledge points according to students' knowledge. However, in flipped classroom, teachers need to prepare appropriate materials to push students at the early stage, and students need to complete knowledge learning by

themselves. In order to urge students to study independently before class, PBL teaching method can be adopted to ask students questions before class and ask them to complete the answers before class, so as to strengthen students' understanding and impression in class. For data pushing, sending questions, correcting homework and other work can be completed with high efficiency using super star learning APP. Hence, the model is based on the Super Star learning platform, supplemented by QQ and Wechat social software. The teaching process of C programming is designed by combining PBL and flipped classroom teaching methods, including three stages: before, during, and after class.

3.3.1 Transfer knowledge before class: The main premise is that teachers fully prepare the materials and carefully design the questions. The teacher will prepare the class materials one week before class and select teaching materials based on the requirements of the teaching syllabus. Considering students' level and subject characteristics, and selecting concise and focused materials and links, such as demonstration videos of MOOCs for Chinese universities that can exercise students' operational ability. With the help of the message release function of the Super Star Learning APP, the course PPT, network video and pre-class questions that need to be reviewed will be released to the whole class, so as to concretize the abstract teaching content and guide the students to conduct independent learning. Through the private message function of Super Star Learning and the chat function in QQ group, teachers can maintain close communication and interaction between teachers and students. Meanwhile, teachers can record key and difficult problems as important explanations and discussions in class. The pre-class teaching model we designed is shown in the Fig 2.

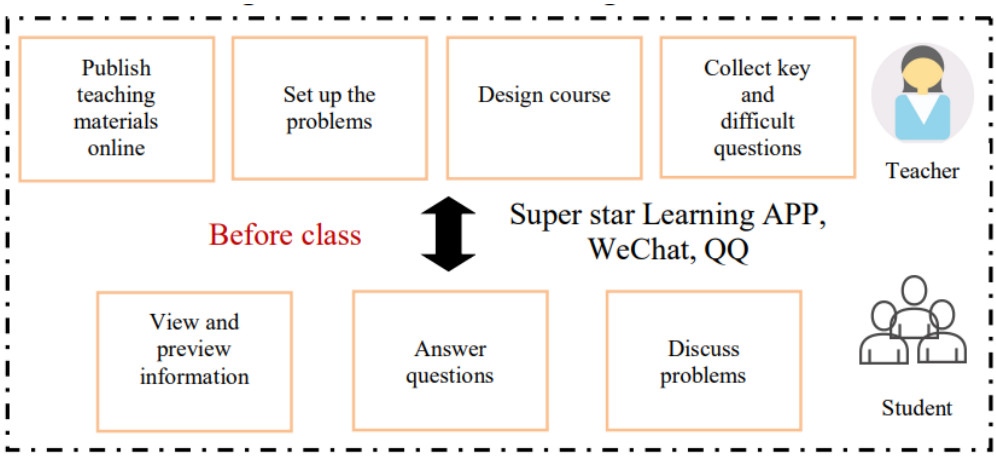

Figure 2 The pre-class teaching model.

3.3.2 Internalize knowledge in class: First of all, the teacher guided the students to solve the problem. In class, teachers should help students to sort out, analyze and summarize self-study knowledge points, and intersperse classroom exercises and part of exercises to test the effect of pre-class learning. The teacher listed the problems collected before class and designed by himself, organized students to discuss on the spot, and corrected the mistakes in students' descriptions. In class, attention should be paid to guiding students to discover the deep rules of knowledge points, and students should be appropriately selected to use the teacher's computer for field operation or code writing. As the classroom organizer, teachers should create a

relaxed, happy and active classroom atmosphere for students, so that students can effectively participate in classroom activities and deepen their understanding through hands-on operation and active thinking.

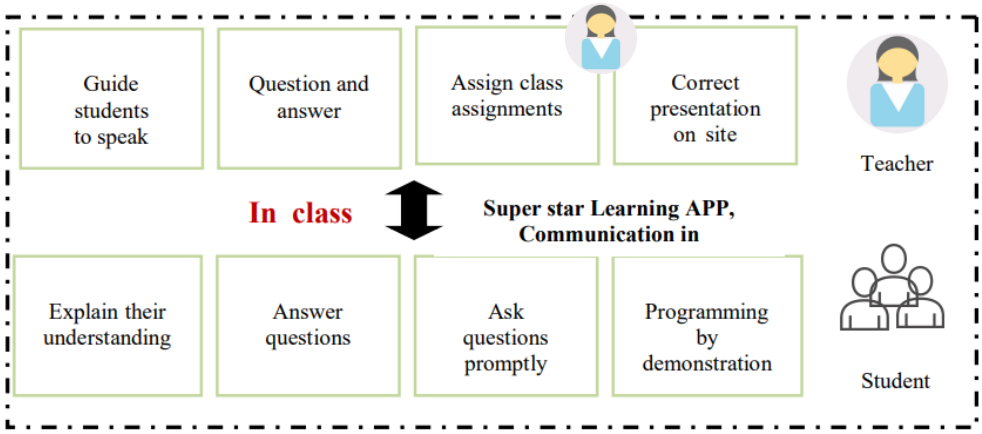

Figure 3 The teaching model in class.

Secondly, students participate in classroom interaction. Because of the use of Super Star Learning platform for classroom records, the teacher posted in class voting, questions, roll call and other activities have relevant records. In the class, students can get the courseware released by the teacher through the platform. According to the content explained by the teacher, they can mark the PPT they are still confused about as "don't understand", which can help the teacher get the key points of the explanation in time. As the main role of the class, students can constantly find new problems and raise them through the Super Star Learning platform barrage, private letters, contributions. The teaching model we designed in class is shown in the Fig.3.

3.3.3 Consolidate and summarize after class: Teacher comprehensive evaluation and teaching reflection namely. The teaching model we designed after class is shown in the Fig.4. According to the class situation and the course report of Super Star Learning Master, the teacher evaluated the teaching status of the C programming course, summarized the knowledge points of this class and the weak points of students, and assigned the corresponding homework. Teachers should pay attention to the discussion of class groups in view of the problems not dealt with well in class. Teachers should pay close attention to students' self-learning before class, classroom demonstration and daily test, and accurately evaluate the degree of students' mastery of curriculum knowledge from an objective and fair perspective. Through the function of Super Star Learning communication, students can actively evaluate teachers' teaching level, classroom organization, problem setting and other aspects. Teachers can adjust teaching methods according to students' feedback, so as to improve their teaching level.

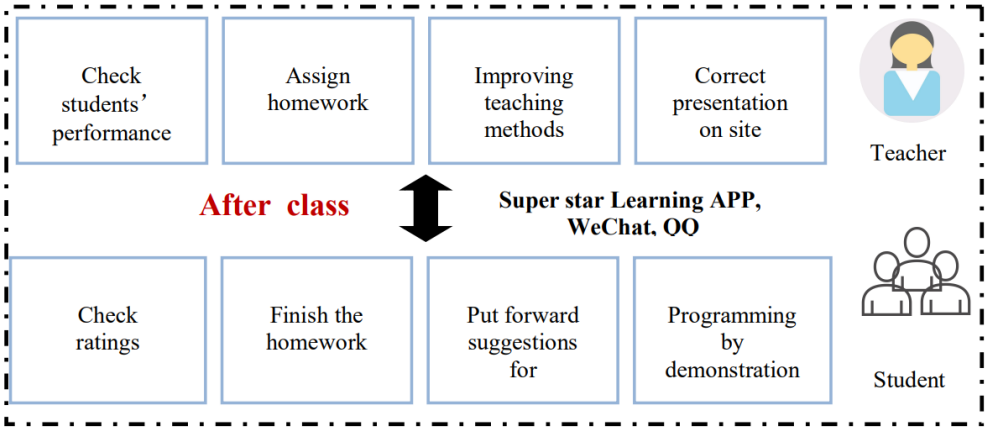

Figure 4 The teaching model after class.

Moreover, students get teaching evaluation. At the end of the class, students will receive a personal evaluation of this course from Super Star Learning channel, which will help them understand their own learning situation, urge them to strengthen their learning, improve their learning methods, and increase the frequency of communication between the classmates. Make full use of network communication and interactive platforms such as Super Star Learning platform, Wechat and QQ, so that students can actively think and communicate after class, and give full play to the supporting role of information technology for students to learn new knowledge.

4 EXPERIMENT RESULTS

4.1 Object of Study

The object of the study is the students of two classes majoring in computer science and technology in the School of Big Data of Baoshan University, Grade 2020. There are 40 students in Class 1 and 41 students in class 2. The ratio of male to female students in the two classes is the nearly same. By drawing lots, Class 1 is selected as the experimental class and class 2 as the control class. The control class adopts the traditional teaching method, while the experimental class adopts the flipped classroom teaching method, that is, the flipped model of "PBL+FC " is adopted for teaching.

4.2 Test Datasets Analysis

In the study, the test scores of the two classes before the experiment and the final exam scores after the experiment were analyzed and compared. In order to make the analysis of test results more scientific and rigorous, the paper carries out sectional statistics on the scores of the two classes. Normal distribution test and significance difference analysis.

4.2.1 Pre-experiment test: In order to check the difference between the performance of the control class and the experimental class before the experiment, the two classes were separately

enrolled before the experiment after two weeks of teaching (8 lessons per class), the students in both classes were tested on what they had learned. And the test results are analyzed and shown in table 1.

Table 1 The test results before the experiment

Class	Class Size	highest score	Lowest score	Average score
Experimental class	40	89	45	68.87
Control class	41	87	44	69.51

As can be seen from table 1, there is little difference between the highest score and the lowest score of the control class and the experimental class, and the average score is similar. In order to further understand the results of the pre-experiment test, IBM SPSS software was used in this paper for analysis. Normal distribution test was conducted on the pre-experiment test results of the control class and the experimental class, and the test data were shown in table 2. For the experimental class, in the 95% confidence interval, the significance levels of K-S test and S-W test are 0.200 and 0.502, respectively. Because the number of samples is small, the S-W test should prevail, and its significance level is greater than 0.05, following the normal distribution. For the control class, In the 95% confidence interval, the significance levels of K-S test and S-W test are 0.200 and 0.189, respectively, which are both greater than 0.05 and follow the normal distribution.

Table 2 Test of normal distribution of test results before experiment

Method of verification	Kolmogorov-Smirnov			Shapiro-Wilk		
	Quantity of statistics	***df***	***Sig.***	***Quantity of statistics***	***df***	***Sig.***
Experimental class pre-test	0.080	40	0.200	0.961	40	0.189
Control class pre-test	0.069	41	0.200	0.970	41	0.502

4.2.2 After-experiment test:

After the flipped classroom experiment of the course C Programming of the experimental class lasted for 16 weeks and a total of 64 teaching arrangement, the control class also adopted the traditional method to teach at the same time. Both the control class and the experimental class had a final examination, and the final scores were statistically analyzed.

The final exam consists of four types of questions: single choice questions (10 questions, 20 points in total), fill-in questions (10 questions, 10 points in total), judgment questions (5 questions, 10 points in total), short answer questions (4 questions, 40 points in total), and programming questions (2 questions, 20 points in total). The test questions focus on the students' grasp of theoretical learning, and also examine the students' comprehensive application ability of knowledge related to advanced language programming

4.2.2.1 Sectional statistics of final grades: The statistics of final examination results are shown in table 3. As illustrated in the table, the passing rate of the experimental class is similar to that of the control class, however, the outstanding rate is much higher than the control class. Based on the analysis of the students' learning situation and the content of the final examination, it showed that the students of the two classes can basically listen attentively in class. In addition, most of the examination content is basic, so the passing rate of the two classes is not much difference. The advantages of the experimental class appear when there are more difficult questions, which indicates that flipped classroom teaching has a better effect and plays a positive role in the internalization of students' theory, practice and literacy knowledge.

Table 3 Sectional statistics of final grades

class	**Class Size**	**Score level**					**Pass rate**	**Outstanding rate**
		0-59	***60-69***	***70-79***	***80-89***	***90-100***		
Experimental class	40	3	7	6	14	10	92.5%	25.0%
Control class	41	8	12	15	4	2	80.5%	4.9%

4.2.2.2 Statistical analysis of performance: The final examination results of the two classes were imported into SPSS software for statistical analysis, found that the skewness coefficients of the final scores of the control class and the experimental class are -0.299 and -0.723 respectively, both of which are less than 0. The results showed that the score distribution of the two classes is left skewed, which indicates that there are more scores above the average in both of the classes, and more students in the experimental class are above the average than the control class. The statistics of final grades confirm the role of flipped classroom in improving students' scores. Moreover, the analysis data was summarized into Table 4. We have also given the histogram of final score distribution of the experimental class and the control class, as shown in Fig. 5 and Fig.6. As can be seen from the figures, the histogram distribution of the control class is steeper, i.e. the normal distribution is steeper, which indicates that the distribution of each grade segment is not uniform. The histogram of the experimental class is smoother, i.e. the shape of the normal curve is smoother, which indicates that the distribution of students in each grade segment is relatively uniform. The above statistical results confirm the role of flipped classroom in improving the overall performance of students.

Table 4 Final grade data statistics

Class	**Class Size**	**highest score**	**Lowest score**	**Average score**	**Standard deviation**
Experimental class	40	99	48	79.8	12.65
Control class	41	94	39	68.6	11.53

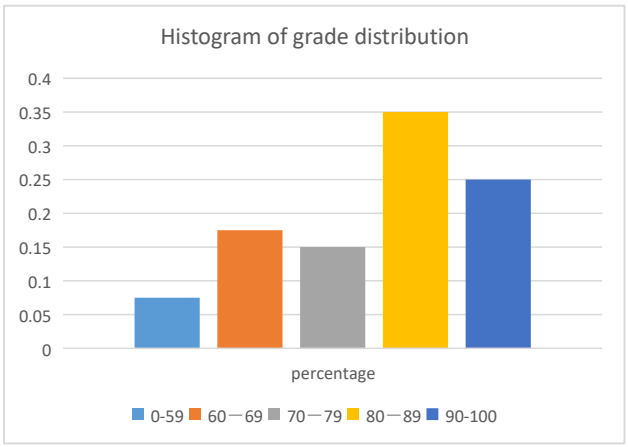

Figure 5 The histogram of final score distribution of the experimental class.

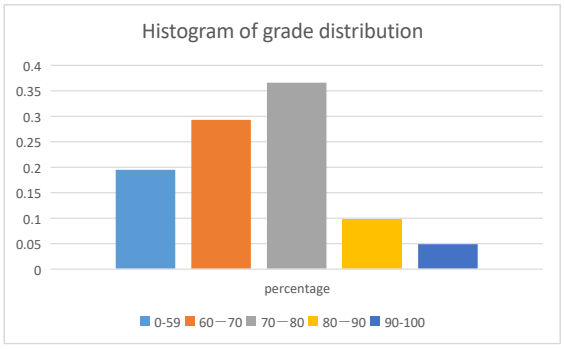

Figure 6 The histogram of final score distribution of the control class.

4.2.2.3 Satisfaction with the teaching model: In addition, to investigate the impact of flipped classroom on grades, the study tries to understand whether students are satisfied with flipped classroom teaching mode from the perspective of students' psychology. Therefore, a total of 81 students in the control class and the experimental class were surveyed after the experiment. All the questionnaires were valid and the recovery rate was 100%. As can be seen from Fig. 7 and Fig. 8, about 80% of the students in the experimental class are satisfied with the teaching mode, while only 56% of the students in the control class are satisfied with the teaching mode of the course of C programming. The results indicate that the application of blended teaching flipped classroom in the course of C programming in the class is effective and in line with students' learning habits.

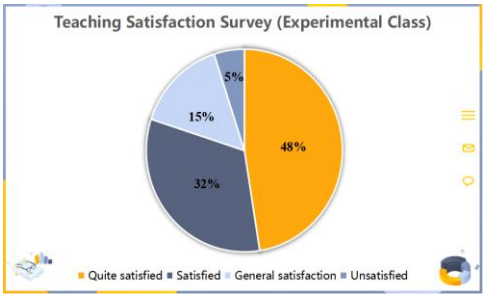

Figure 7 The teaching satisfaction survey results of the experimental class

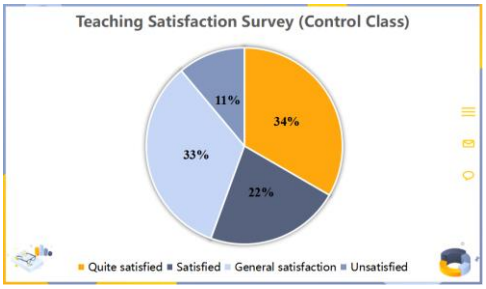

Figure 8 The teaching satisfaction survey results of the control class

5 CONCLUSION

Based on the online learning platform Super Star Learning, the study carried out the flipped classroom research of C programming course, designed a "PBL+FC" flipped classroom teaching model based on blended teaching, and used the online learning platform to carry out research on the feasibility of flipped classroom teaching, design strategies and specific cases, and evaluated the teaching effect of the flipped classroom model. Finally, through the quantitative and qualitative analysis, the research conclusion is drawn, i.e., through the comparative experimental analysis of the two classes, it is concluded that the flipped classroom teaching of C programming has a good effect on the improvement of students' grades and quality.

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