A Competitive Blended Learning Model of Computer Teaching

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Abstract—Universities are encouraged to popularize blended learning by digitalizing and reusing teaching resources. This paper proposed a competitive blended learning model of computer teaching. It is not only a creative learning model but also a major innovation in curriculum reform that changes the instructor-based stand-and-deliver teaching scheme into student-based proactive learning. A feasible teaching method is designed to lead the way for instructors. Competitive strategies are introduced to arouse students' desire to win and become competitive for instructors' recognition. A multi-factor evaluation method is proposed to measure the effectiveness and availability of the proposed method. A comparative case study is carried out on computer students at Shantou Polytechnics. Instructors follow the teaching method to implement the proposed method. Students' performances are evaluated during the course of C programming. Compared with the blended learning model and traditional learning model, the proposed model shows significant improvement in teaching effectiveness and general availability in future.

Keywords-Blended learning; competitive strategy; computer teaching; learning model

1 INTRODUCTION

Blended learning is an educational model for instructors that combines in-person instruction with online learning activities. It enables students to engaging online activities at their preferred pace and time. Universities are encouraged to popularize blended learning by digitalizing and reusing teaching resources.[1, 2, 14] Lalima et al. list the benefit of blended learning and the prerequisites of its implementation.[3] Wang et al. proposed an achievement-oriented blended learning model to optimize the design and practice of curriculum content.[4] Ma et al. conducted an empirical analysis of students' commitment to more than 600 college students by a questionnaire method.[5] Kachalova et al. set guidelines for organizing blended learning in chemistry lessons.[6] Hains et al. discussed that facilitating team teaching for blended learning is a purposeful combination of online interactive activities with face-to-face learning.[7] However, blended learning requires sufficient experience in the use of computers, which could be challenging to some instructors and students. In computer teaching, it is no longer a blocker.

Online learning platforms, especially computer teaching and programming platforms, have been gradually catching on.[8] Johnson et al. explores the experience of contributors to a massive open online courses-designed for university students.[9] Zeng et al. discussed the application of small private online course in flip classroom model.[10] Guan et al. conducted a comparison analysis of over 200 online education products to the trend lying behind brisk market of online education.[11] The challenge of teaching through the abovementioned online learning integration is the extra time cost of overburdened instructors. Instructors have to revamp the entire course and optimize the teaching process for the online learning platform.

Competitive teaching, as its name suggests, is a duty-driven method that enables students to accomplish duties in the form of competitions. Lee et al. analyzed the characteristics of competitive learning by using the repertory grid technique to figure out the elementary school students' receptivity to competitive learning.[12] Wen discussed the difference between competitive and total immersion methods in swimming teaching.[13] Ling et al. [15] figured out that the implementation of after-school assignments was effective in improving students' learning achievement. [15] The competitive teaching method is more focus on learning competitive techniques via competitions, which is commonly applied in physical teaching.

This paper proposed a competitive blended learning model in computer teaching and carry out a case study of a C programming course at Shantou Polytechnics. The method optimizes the teaching process and improves learning outcomes.

2 COMPETITIVE BLENDED LEARNING MODEL

2.1 Training Objective of Computer Students

In a word, the training objective of computer students is to meet the basic requirements of qualified IT engineers. Students are required to develop strong practical engineering skills, analytical skills and problem-solving skills so that they can undertake tasks independently in enterprise IT projects.

Programming skill is the fundamental requirement. Thus, programming courses become the backbone of computer studying. Generally, a student takes two to four programming courses at the university.

2.2 Teaching Objective

Develop high-quality courses is an important link to attain the training objectives. Programming courses, in which, is an inevitable and crucial component.

The teaching objective of programming courses are usually summarized as: (1) To build up programming ideas. (2) To learn the characteristics of the programming language. (3) To write program using the programming language.

2.3 Teaching Method

The teaching method of the competitive blended learning model in computer teaching includes five steps, which are given in Fig. 1.
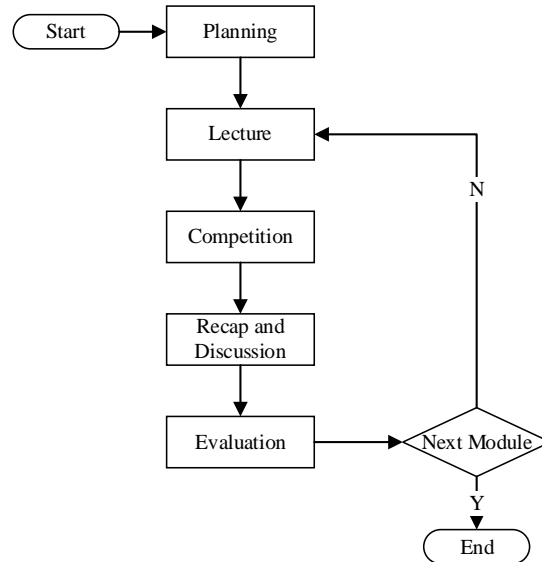

Figure 1. Teaching method of Competitive Blended Learning.

2.3.1 Planning: Instructors perform modularized design to divide teaching content into knowledge-based learning modules according to teaching objectives. Also, teaching plan adjustment is required in the constraints of online and offline resource limitations.

2.3.2 Lecture: At the beginning of each learning module, instructors offer in-person lectures including theory learning. In the offline learning session, instructors have to keep knowledge points straight, which gives students a learning vision of the knowledge module. Taking information in the lecture before practissing programming skills follows the path from theory to practice.

2.3.3 Competition: Holding competition according to the learning content in the module. Tests are created to evaluate the proficiency in applying C programming knowledge to solve problems. Test includes problem descriptions, data ranges, input/output samples and tips. Instructors allocate test points for each test. The harder the test is, the higher the test points is. Students register competitions via the invitations. Once student accomplish the competition, they can view the ranking list and figure out their test points and mistaken answer. And also, of course, those information are available to instructors.

2.3.4 Recap and Discussion: Once all students accomplished the competition, instructors are required to do a deep dive analysis of the competition result and organize a recap session. In

the recap session, instructors explain the knowledge in commonly mistaken answers and help students out with queries.

2.3.5 Evaluation: The evaluation criteria included two parts, peacetime performance (40%) and term examination (60%). Studying path analysis of online learning is applied to dynamically record the knowledge that students have been visited and the competitions students have been accomplished. It is a qualitative and quantitative evaluation method that allows instructors to follow the traceable peacetime achievement. The term examination is carried out at the end of the term. Scores can be classified into excellent (85-100), good (75-84), medium (60-74) and poor (0-59) grades.

2.4 Competitive Strategies

Competitive teaching usually uses the intrinsic desire to win to motivate students to learn. Three competitive strategies are adopted in the competitive blended learning model.

2.4.1 Competition: Peacetime performance measures students' learning progress, score is given from both classroom behavior and competition. In this type of setting, students become competitive with each other for the best score.

2.4.2 Recognition: Students tend to show more effort during learning when there are other competitors involved. Instructors need to identify their achievements and responses in time, which consequently, leads to their competitive behavior for instructors' recognition.

2.4.3 Digitization: The The fundamental technology that lies in blended learning is digitization, which is a breakout for tracing teaching and learning activities. In a competitive blended learning model, the teaching method hinges on the collected data. For instance, recap and discussion will become a stand-and-deliver session without insights from collected competition data.

3 CASE STUDY

3.1 Teaching Subject

C programming course is selected as the teaching subject, which is normally the first programming language learned by students major in computer. The reasons to start programming practicing from learning C is: (1) Many computer courses build up experiments on C such as Data Structure; (2) C is a low-level language that help students better understand system architecture; (3) high-level languages, including Java, C++, Python, etc., are based on C language.

3.2 Learning Modules

As shown in Table 1, below five learning modules are the main components of knowledge in the C programming course. The class hours of learning content can be slightly different. For instance, L1 is where students start the C programming journal. Therefore, it takes 24 hours even though the knowledge is pretty basic.

Table 1 Knowledge Module Information

Learning Module	Learning Content	Class Hours[a]
L1	Variables and Operators	24
L2	Conditionals	16
L3	Loops	24
L4	Arrays and Strings	24
L5	Pointers, Functions and Structures	16

a. 104 hours in total. The other four hours for revision.

3.3 Competitions

For each learning module, a competition is held to help students understand knowledge by solving programming tests. Table 2 links the learning module information to the competition information.

Table 2 Competition Information

Competition	Learning Module	Number of Tests	Total Test Points
C1	L1	8	800
C2	L2	5	500
C3	L3	6	900
C4	L4	6	800
C5	L5	4	400

Generally, there should be 5 to 6 tests in a competition, each test worth 100 test points. C1 has 8 tests because knowledge in L1 is basic and crucial. The complexity of tests in C3 and C4 contributes to the high total test points. Knowledge in L5 is confusing for most students. Both students and instructors benefit from the little pruning in C5.

3.4 Teaching Object

Computer major students in Shantou Polytechnics are chosen as teaching objects. The class information is given in Table 3.

Table 3 Class Information

Class ID	Major[a]	Enrollment Year	Number of Students
S1	Software Technology	2021	54
S2	Software Technology	2021	50
M1	Mobile Technology	2021	55
M2	Mobile Technology	2021	53
D1	Digital Media Technology	2021	55
D2	Digital Media Technology	2021	52

a. All majors are belongs to *Computer Application* (major category).

Since the objective of the comparative experiment is to figure out whether or not there is a statistically significant change in the response to competitive blended learning model, the teaching object has to be comparable and similar.

The case study was conducted in the spring semester of 2021. All students in the six classes are entering freshmen, and most of them have little or no programming experience.

Six classes are divided into three groups. Group S is the experiment group and group D is the control group, which are used to test whether the competitive blended learning model can influence the result. Group M is designed to isolate competition strategies' effect on the experiment and further help rule out confirmation bias.

3.5 Learning Model Comparison

As described in Table 4, Students from six classes are to act as guinea pigs for the proposed learning model. Classes are classified into three groups by major. A competitive blended learning model are adopted in group S and group M. In which, competitive strategies are introduced in S. Besides, the teaching plan adjustment is made due to the class hour increasement. Group D keep using the teaching plan and learning model as it was in the past three years.

Table 4 Learning Model Information

Group ID	Class ID	Competitive Learning	Blended Learning	Teaching Plan Adjustment	Class Hours
S	S1	√	√	√	108
	S2	√	√	√	108
M	M1	-	√	√	108
	M2	-	√	√	108
D	D1	-	-	-	84
	D2	-	-	-	84

3.6 Online Platform

Luogu is an online test system founded in 2013, which is initially developed to help NOIP, NOI and ACM competitors to program online. Due to the availability and user-friendliness, the online learning sessions are held on Luogu.

The online platform charges CNY 700 a year, which can support organizations of up to 2,000 users. The cost per class each semester can be calculated by

$$\frac{A(S+I)}{2U} \tag{1}$$

In which, A is the annual fee; U is the maximum number of users supported by online platform; S and I are number of students and instructors of a class.

The estimated cost works out to CNY 10.5/semester for each class.

Instructors are encouraged to use online analysis services to log students' learning activities and trace their behaviors. Thus, students' performance is traceable throughout the course.

Before starting the course, instructors are encouraged to join a training session to learn how to make the most out of online platform. Generally, the training session takes less than 10 hours.

3.7 Evaluation Method

In this section, an evaluation method is proposed. Five evaluation factors are considered in the method from students, instructors and universities' aspects.

3.7.1 Practising Time: Practicing time is designed to evaluate how much time a student is willing to spend on their hands-on tasks, including classroom programming hours, online learning hours and extra time they devote to related online practice. It can be calculated by class hours in teaching plan and the activity data in online platform.

3.7.2 Classroom Learning Time: Classroom learning time, as the name implies, is the total hours of classroom learning. In the traditional learning model, class room learning time accounted for 70% of class hours. Whereas in the competitive blended learning model, the number drops to 50%.

3.7.3 Time Cost: Time cost is an intuitive figure to evaluate instructors' workload. Class hours, course preparation and training sessions before starting the course are included. What's more, it can also be used for universities to make budgets.

3.7.4 Economic Cost: Universities are required to control budgets and costs. A big-money plan will not be approved no matter how great the vision is. There are basically two parts in economic cost: service fee charged by online platform and class hour-based wage for instructors.

3.7.5 Final Score: Final score is a criterion to evaluate how much a teacher gets teaching results and how much a student learns from the course. It can be calculated by the abovementioned evaluation criteria in teaching method.

4 RESULTS AND DISCUSSION

4.1 Analysis of Peacetime Performance

The comparison analysis of peacetime performance scores among the three groups is given in Table 5.

The average score rank from high to low are: S, M and D. Group S shows the effectiveness of competitive blended learning. Group M can be seen as control group in ablation experiment, which confirm the validity of competitive strategies.

The pass rate in all groups is close, which indicates most students are capable to accomplished the learning tasks. But it is worth recalling that, without online learning platform, instructors have to devote much more time in tracing students' behavior and logging peacetime performance.

The deep gap of excellent rate between group S and others entitled to a bold conclusion: competitive strategies are the motivation for students to learn, grow and finally stand out.

Table 5 Peacetime Performance Score

Group ID	Average Score	Pass Rate	Excellent Rate
S	91.57	97%	84%
M	84.32	100%	50%
D	81.37	97%	55%

4.2 Analysis of Term Examination

The comparison analysis of term examination scores is given in Table 6.

Group S tops the list and, by inference, the competitive blended learning model is still in effect. The term examination score of group D is a bit better than group M. Since the term examination is a closed-book written examination with no notes allowed, the large quantities of online programming did not realize in any significant score improvement.

For pass rate and excellent rate, the gap of between group S and others have widen. The increased disparity attribute to the difficulty and discrimination requirements of term examination.

Table 6 Term Examination Score

Group ID	Average Score	Pass Rate	Excellent Rate
S	66.59	69%	28%
M	50.26	31%	5%
D	55.14	47%	7%

4.3 Analysis of Final Scores

Table 7 gives the statistics of final score. The average scores in all three groups are above 60 and the overall pass rate reaches 80%, which proves to achieve the teaching object of the course.

Table 7 Final Score

Group ID	Average Score	Pass Rate	Excellent Rate
S	76.59	88%	33%
M	65.63	75%	8%
D	65.64	79%	6%

As shown in Fig. 2, grades are highlighted in different colors. The distribution of final score aligns with statistical characteristics of peacetime performance and term examination.

The vast majority get a Good or Medium. Only in those classes that adopted competitive blended learning model, the excellent rate is higher than failure rate.
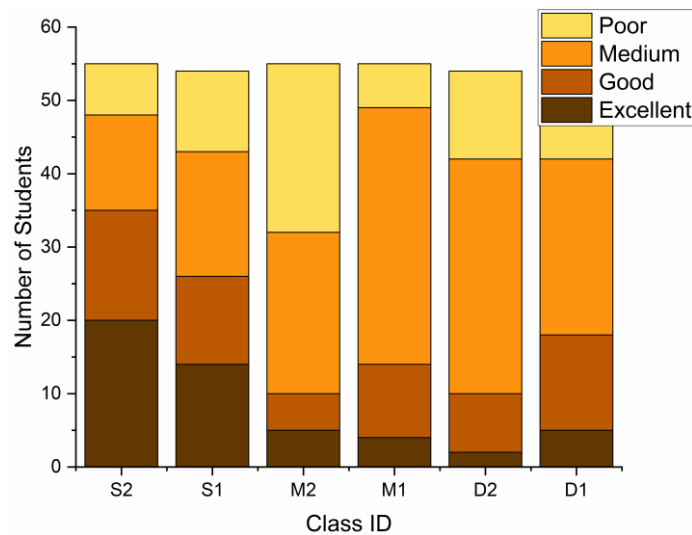

Figure 2. Distributions of Final Score.

4.4 Evaluation

The evaluation factors are worked out and given in Table 8.

Economic cost of group S and M are the same, 29% higher than group D. Service fee of online learning is account for a substantial part of the difference.

Time cost of group D almost doubled, piles of manual work in teaching preparation should take the blame.

Practicing time disparity indicates the positive influence competitive blended model exerts over the students. Students in group S on average spent 81 hours in practice. The expected practicing hour designed in teaching plan, for reference, is 54 hours.

The difference of classroom learning time is negligible.

Final score of group S, in line with expectations, rank the first. It is the most straight forward approach to evaluate teaching achievement of competitive blended learning model.

Table 8 Evaluation Factors

Factor	Group ID		
	S	M	D
Economic Cost (CNY)	2872.5	2872.5	2226
Time Cost (h)	74.8	74.8	130.2
Practicing Time (h)	81	64.8	25.2
Classroom Learning Time (h)	54	54	58.8
Final Score	76.59	65.63	65.64

Fig. 3 is a radar chart of standardized evaluation factors. Economic cost and time cost are negative indicators; therefore, they are transformed into economic effectiveness and time effectiveness respectively. These five standardized evaluation factors formed a pentagon, the area of pentagon present the effectiveness and availability of the learning model.

Once transform the value of evaluation factors into five grades, time effective become the most conspicuous sign. Besides, practicing time is an indispensability part of evaluation method. The other three factors are less distinctive.
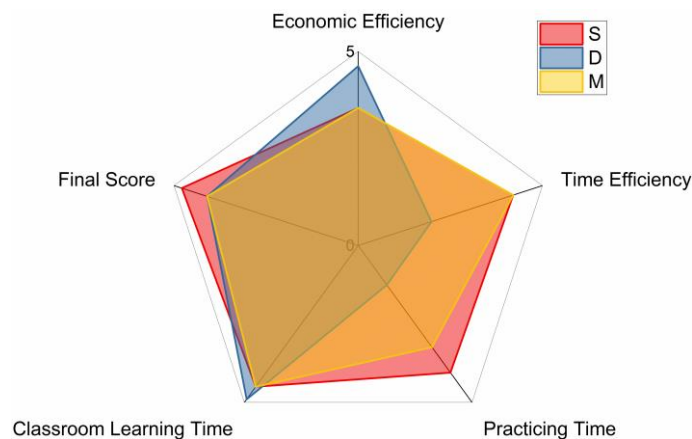

Figure 3. Evaluation.

5 CONCLUSION

This paper proposed a competitive blended learning model for computer teaching. To avoid confirmation bias, a comparative case study is carried out on computer students in Shantou Polytechnics. The major conclusions were drawn:

1)A competitve blended learning model is proposed to improve teaching efficiency without dramatically increase teaching cost. Students stay motivated to accomplish the course in both online and offline learning. Instructors are much more productive by applying the proposed model. It is not only a creative learning model, but also a major innovation in curriculum reform that change the instructor-based stand-and-deliver teaching scheme into student-based proactive learning.

2)The teaching method of the proposed model is innovative and adapt to the era of pandemic threat. The five steps of teaching method is summarized as: plannig, lecture, competition, recap and discussion and evaluation, which give a practical method for instructors to implement competitive blended learning model.

3)Competitive strategies are introduced to arouse students' desire to win and become competitive for instructors' recognition, which is the vital part that enables student's practice ability. Students prefer praticing online to win the competition, rather than programming alone. The comparison of practicing time shows that blended learning contributes to 157% increasement, and competitive strategies take one step further by raising the number to 221%.

4)A multi factor evaluation method is proposed to measure the effectiveness of competitve blended learning model. The influence factors are economic cost, time cost, practicing time, classroom learning time and final score. The difference of economic cost indicates the availability of proposed model. Practicing time is the most distinguishable factor to discriminate the proposed method from others. Final score is an intuitionistic and quantitative index to evaluate the effectiveness.

5)This paper carried out a case study on computer students in Shantou Polytechnics. These students are from six classes and divided into three groups. Instructors follows the teaching method to implement the proposed method. The proposed evaluation method is adopted in the case study. Compared with blended learning model and traditional learning model, the proposed model shows significant improvement of teaching effectiveness and general availability in future.

6)Students, instructors and universities are benefit from the competitive blended learning model. Students acquire more knowledge and experience. Instructors escape from being overworked. The digitalization and infrastructure of the universities are the foundation for competitive blended learning model. It is universities' responsibility to apply innovative learning model in teaching and the advantages of the proposed model largely outweigh the disadvantages.

7)Further studies should be carried out to roll out proposed method to other fields, especially non-engineering major, to verify the effectiveness.

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