

Research of an online-offline blending teaching model for the post COVID-19 era —Using a C programming language course as an example

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Abstract—This paper aims to study the new changes in higher education in the post COVID-19 era and proposed an innovative Online-to-Offline (O2O) blending teaching model, named BOPPPS-SPOC by tracking a C programming language course. BOPPPS-SPOC indicates implementing BOPPPS mode for SPOC (Small Private Online Course). BOPPPS is an acronym for 6 components: Bridge in, Objective, Preassessment, Participatory learning, Post-assessment and Summary and it makes the classroom teaching arrangement more logic and rationality. The new changes are: (1) Teaching Methods: From separated online and offline teaching to an online-offline blending teaching. By adopting the new BOPPPS-SPOC method, the traditional offline and online independent teaching, implemented in a serial way, is optimized into offline and online blending teaching, implemented in a cross-parallel way, and it effectively expand the time and space scope of classroom teaching; (2) Course Evaluation: From single-dimensional evaluation to multi-dimensional evaluation. It focuses on the construction of a fusion evaluation system, mainly including the formative evaluation of teaching process and the sum. Finally, a survey from an authoritative research institution is conducted to 334 universities in China. It shows about 95% of students are able to adapt to an O2O blending teaching.

Keywords—SPOC, MOOC, BOPPPS, the Post COVID-19 Era, Course Evaluation

I. INTRODUCTION

During the outbreak of the novel coronavirus (COVID-19) pandemic, to solve the problem of students being unable to safely return to school and to fully protect their right to education, “Suspending Classes Without Stopping Learning” was launched by the Chinese government, and it required universities to actively carry out all their teaching activities online as schools across the country were closed to contain the spread of the virus. The focus was to ensure the continuation of learning, teaching progress and to ensure that the quality of online teaching was substantially equivalent to the quality of offline teaching. As of May 8, 2020, the statistics show that after the outbreak of the novel coronavirus in 2020, more than 1454 colleges and universities moved to online teaching, and 1.03 million teachers offer 1.07 million online courses, the total number of online teaching time was more than 12.26 million hours. More than 17.75 million college students participated in online learning and the total number of online visits was more than 2.3 billion [1]. This kind of large-scale online education witnessed by the education system during the pandemic prevention and control period was an unprecedented initiative in history.

With the improvement of the pandemic situation in China, China is about to take the leading role in entering the post-pandemic era. Major changes in higher education are likely to occur and amongst these changes will be the emergence of an

Online-to-Offline (O2O) blending teaching model. This model is most likely to become the basic form of education in future.[2] The reasons being that: although the influence of online teaching will be weakened after the pandemic, its advantages over offline teaching will inevitably persist. Online teaching will change from being an “exploratory and transience” activity into a “routine and sustainability” activity. Hence a new form of teaching will emerge that fuse both offline and online teaching.

Under this background, this paper proposed an innovative Online-to-Offline (O2O) blending teaching model named BOPPPS-SPOC by tracking a C programming language course. BOPPPS-SPOC indicates implementing BOPPPS mode for SPOC (Small Private Online Course). BOPPPS is a famous model designed by Canadian Teacher Skills Training and it divides the classroom teaching into Bridge in, Objective, Preassessment, Participatory learning, Post-assessment and Summary six links. [3] We thought BOPPPS-SPOC had distinct advantages over traditional O2O teaching. In traditional O2O teaching, offline and online are independent and integrated superficially. But in BOPPPS-SPOC mode, offline and online acted as an integrated whole and they have a mutualistic relationship, and changes in each side will have a direct impact on the other side, thus giving birth to a new dual relationship. [4-6] In the post-pandemic era, the O2O blending teaching will further highlight this amalgamation, not a simple form of “offline + online”, but for the best result of “1+1 > 2”, which means the deep integration of content is greater than the simple merger of forms.

To explain the advantages of BOPPPS-SPOC, Section II describes two innovations of online-to-offline blending teaching in teaching methods and assessment models. Section III analyzed the effectiveness of BOPPPS-SPOC through questionnaire, which is conducted to 334 universities in China by an authoritative research institution.

II. INNOVATIONS OF ONLINE-OFFLINE BLENDING TEACHING

A. Innovations in Teaching Methods: from separated online and offline teaching to an online-offline blending teaching

Before the pandemic, it mainly adopted the teaching method of “offline teaching as the mainstay, online teaching as the supplement”. This kind of offline and offline independent teaching mode had some limitations in terms of “unification of progress, centralization of learning, and standardization of content”, etc. During the pandemic period, the main advantages of online teaching were clearly demonstrated. Teaching was no longer restricted by time and space meaning that learning could be done anywhere and at any time. It provides a strong argument in favor of an O2O blending teaching mode in the post-pandemic era.

The traditional O2O independent mode, implemented in a serial way, is to be optimized into O2O blending teaching, implemented in a cross-parallel way. Thus, it effectively extending and expanding classroom teaching. In practice, the major challenges faced when developing this O2O blending teaching model are how to decompose, connect and integrate the respective contents of online and offline teaching contents. After long term practice, a blending teaching model based on the BOPPPS-SPOC was proposed. This model did not only solve the problem of not having an "effective teaching structure" in the teaching process but also stimulates the enthusiasm of students to participate in classroom interactive learning. On the one side, BOPPPS-SPOC divided the teaching process into various linkable sub-components with clear boundaries and relevance. It adopts the BOPPPS teaching paradigm which can optimize the experience-based teaching process into a standardized process. Therefore, BOPPPS-SPOC makes the classroom teaching arrangement more logic and rationality. On the other side, it transformed the learning process from being a "passively accept knowledge" to a process of "passively accept knowledge + actively explore questions".

Specifically, we subdivided the six links of BOPPPS into 16 micro-actions, which makes it easier to follow and clearer for implementing, as shown in Figure 1: self-study before class, active learning in class and consolidation of knowledge after class. Amongst these three stages, the before-class stage is conducted online and includes the first three parts of BOPPPS, they are Bridge-in, Objective, Pre-assessment; the in-class stage refers to Participatory learning, which is the main body of BOPPPS and conducted offline; The after-class stage is also conducted offline and includes the last two parts of BOPPPS, they are Post-class assessment and Summary.

Here we take the "Function Chapter" in C programming language as an example to explore the application method of this O2O blending teaching model base on BOPPPS-SPOC, as shown in Table 2.

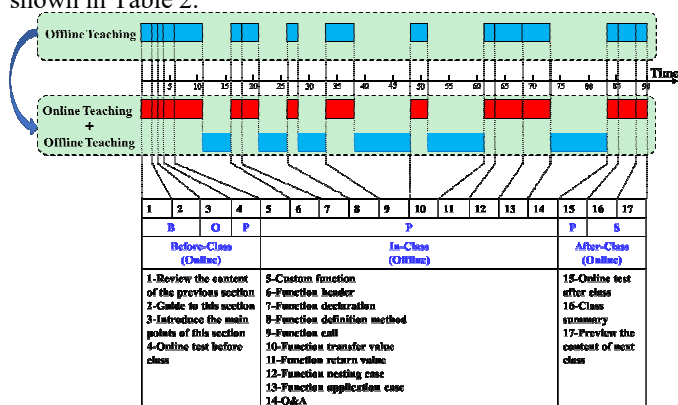


Figure 1 using BOPPPS-SPOC blending method to design teaching contents (taking the function chapter of C course as a case)

1) Bridge-in: Guide students into the lesson

The purpose of the Bridge-in is to introduce the learning content to the student, help them to understand the learning content, generate interest in the content and motivates them. The introduction should be concise and lively and suitable for online teaching. Usually, the strategies that can be used for the

Bridge-in include: asking funny but thought provoking questions, indicating how already learnt topics link to the new topics, showing interesting pictures, videos, charts, examples, indicating the reasons and importance of the new content, etc.

2) Learning objectives: Clarify what needs to be mastered in this lesson

Learning objective refers to the expected outcomes and ability levels that students should achieve through learning. It is the basis of teaching and learning, which enables teachers to better design teaching content and also enables students to quickly understand the purpose of learning. The learning objectives should be brief and concise while taking into account the basic requirements of teaching, as well as the level of knowledge and learning ability of students. According to Bloom's Taxonomy, clear and appropriate learning objectives should be determined from three key aspects: knowledge, ability and quality. In general, knowledge means knowing and remembering, ability refers to comprehension and application of the knowledge learned; quality includes analysis, synthesis and evaluation. When applying, it's best to pre-set some quantitative objects estimated according to the students' learning situation. For example, $\geq 80\%$ students can use the function correctly; $\geq 60\%$ students can understand the Function Call process; $\geq 40\%$ students can know the principle of Single Responsibility and Separation of Concerns in modular programming.

3) Pre-Assessment: Understand students' learning situation and adjust teaching content

Pre-assessment is an important prerequisite for carrying out effective teaching activities. It enables teachers to have a deeper understanding of students' learning (knowledge reserve, preview situation, learning ability and interest, etc.), and to adapt their teaching contents and tempo on time. Further, it also allows students to conduct self-evaluation and to study in a targeted manner.

Pre-assessment should be designed according to students' abilities, teaching contents, and teaching objectives. It can be implemented through questionnaires, exams, homework, questions and discussions. Question types can include multiple-choice questions, fill-in-the-blank questions, true or false questions, questionnaires, preview reports etc.

4) Participatory learning: Teacher-student interactive teaching based on problem inspiration

Participatory learning refers to adopting an active learning strategy that requires students to actively participate in learning to achieve teaching objectives. It mainly adopts the "offline + online" blending teaching model, emphasizing the centered role of students and the supporting role of teachers. BOPPPS-SPOC effectively realized the mutual integration of network "virtual" teaching and classroom "face to face" teaching. In participatory learning, there is a two-way interactive relationship between teachers and students. ① teachers focus on the explanation of core knowledge and difficult problems of the lecture during classroom face to face teaching. The classroom teaching is divided into two stages: the first stage is a knowledge review, mainly to sort out online self-study contents. According to the online learning

behavioral data of students recorded by the teaching platform, teachers can understand the students' pre-class preview and learning challenges. Thus, teachers can accurately identify the key and difficult part of the lecture, which help students learn the contents of this lesson systematically to better consolidate the information. The second stage is the learning and internalization stage, this involves raising questions, individual thinking, solving problems, group discussions, presentation reports, teacher interpretations, summary evaluations and other activities. One of the most important is problem-driven and it can significantly help students to master the information and improve their analytical abilities in problem solving. ② Students can complete interactive learning with teachers and classmates online. Teacher-student interaction means students can independently solve the more difficult and comprehensive problems under continuous enlightenment, questioning and guidance from teachers. As a result, students' shallow understanding of knowledge is gradually deepened in mutual discussion, and the originally scattered fragments of knowledge are gradually integrated and systemized. Moreover, through online collaborative learning, students can deeply understand knowledge points, construct a knowledge system, and realize knowledge internalization through continuous in-depth exploration.

5) Post-assessment: testing teaching effectiveness

Post-assessment is an evaluation method that seeks to understand whether students have achieved the teaching objectives. Based on the results teacher can make some necessary adjustments, such as improving teaching methods, optimizing teaching contents, etc., and students can assess their own learning situation in time and summarize their learning gains objectively.

In general, different post-assessment methods can be used for different course contents. For instance, for theoretical knowledge, teachers can use the methods of question and answer sections, multiple-choice questions, matching questions etc. For applied knowledge, teachers can design some engineering problems that are closely related to reality, to cultivate students' ability to use the knowledge they have learned to solve problems independently. For practical knowledge, teachers can ask students to describe specific operation's steps, and when conditions permit, students can be asked to do live demonstration or operations. For key knowledge, teachers can let the students summarize and summarize to understand their mastery of knowledge.

6) Summary: review key knowledge and preview the content of the next lesson

The summary is designed to help students review and organize the learnt material and to reflect on whether the learning goals would have been met. The summary serves as a link between the past and the future. It is not only a summary of the contents of the lecture, that provides teachers and students with opportunities for reflection but also serves as an introduction to the contents of the next lecture. The summary can be conducted both online and offline. Online, the teacher can summarize the teaching contents, clarify the key points and important issues, assign homework and predict the content

and requirements of the next class and assign homework, in order. Offline, through on-site Q&A, teachers can promptly solve the students' deficiencies and obstacles in this class, so as to facilitate their review after class.

B. Innovations in Assessment Models: From single-dimensional evaluation to multi-dimensional evaluation

The evaluation system based on the BOPPPS-SPOC O2O blending teaching model is comprised of two parts: online evaluation and offline evaluation. It focuses on the construction of a fusion evaluation system, mainly including the formative evaluation of teaching process and the summative evaluation of teaching effectiveness. [7] By strengthening mutual cooperation between online evaluation and offline evaluation, the evaluation structure will be more scientific and reasonable, and the evaluation results will be more comprehensive and objective, as shown in Table 3.

1) Construction of the teaching evaluation system

It includes two dimensions, evaluation types and evaluation attributes. ① Evaluation types: according to its content and characteristics, the evaluation types can be subdivided into form stage evaluation, comprehensive evaluation and conclusive evaluation. Specifically, Stage evaluation is the evaluation of students' learning situation and learning experience of each stage (before, during and after class) in a class. A comprehensive evaluation is an overall investigation of the student's mastery over the knowledge of the course and the construction of the knowledge system over a certain period (usually one semester). Conclusive evaluation refers to making a final assessment of the entire learning process of each student. ② Evaluation attributes: it refers to the composition of the evaluation system, which mainly including the evaluation object (evaluate what) and evaluation elements (evaluate based on what), evaluation methods (online, offline, in class, and out of class), evaluation forms (based on subjective qualitative evaluation and objective quantitative evaluation).

2) Teaching effectiveness evaluation system

Traditional teaching evaluation suffers from the problem of only focusing on the final results and neglects the learning process. They only focus on the mastery of curriculum knowledge and lacks the means to evaluate the student's learning experience, feelings, attitudes, etc. The BOPPPS-SPOC blending teaching model makes full use of the massive teaching data generated by online teaching to discover learners' learning preferences and learning patterns and form feedback on students' learning situations. BOPPPS-SPOC effectively combines the subjective evaluation of learning process and objective evaluation of learning results. Obviously, process evaluation is more difficult than result evaluation and it involves qualitative evaluation such as learning attitude and learning ability, and its evaluation criteria are relatively vague. Therefore, this thesis mainly focuses on the study of learning process evaluation. According to the characteristics of O2O blending teaching, the main evaluation indicators and corresponding weights have been established. Some evaluation criteria are shown in Table 4. [8]

III. OUTCOME OF THE EXPERIMENT

The analysis of the implementation of O2O blending teaching in this paper is mainly based on the online teaching survey questionnaire issued by the online teaching research group of Xiamen University Teacher Development Center. A total of 334 universities, 13997 teachers and 256504 students participated in the survey. [9] To ensure the objectivity and accuracy of data analysis, the SPSS16.0 analysis tool and KMO & Bartlett test method were used. The results of the analysis were as follows:

A. Analysis of hybrid learning

Figure 3 shows the evaluation of students' online self-learning ability. The data shows that students can be divided into three groups: Highly self-disciplined, $\approx 20\%$ of students are fully able to adapt to O2O blending teaching; Relative self-disciplined, $\approx 75\%$ of students are able or basically able to adapt to O2O blending teaching; Low self-discipline, only 4% of students are not able to adapt to O2O blending teaching. Overall, young students can easily adapt to online learning and can maintain a more positive learning attitude. Only 5.91% of students chose that they failed to master the knowledge points of the course.

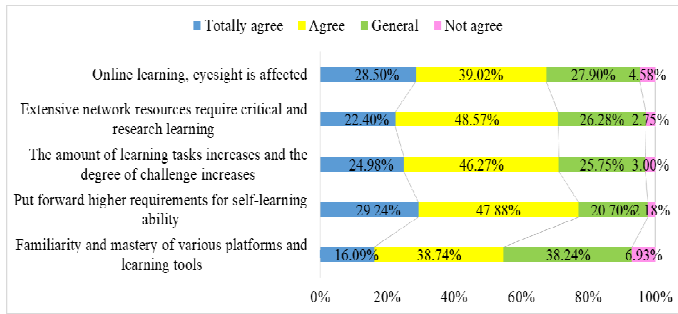
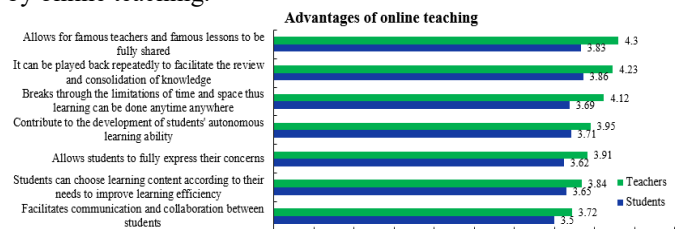


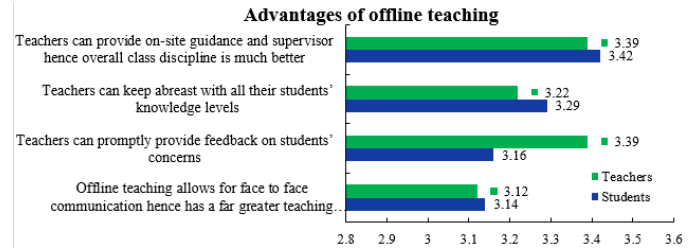
Figure 3 Challenges of online learning to students

B. Analysis of the effect of hybrid teaching

In order to have a more comprehensive and accurate understanding of the effects of online teaching and offline teaching a questionnaire survey was conducted for both teachers and students, as shown in the table. The survey results show that no matter how online teaching changes face-to-face communication between teachers and students remained an integral part of teaching and cannot be replaced by online teaching.



(a) Advantages of online teaching



(b) Advantages of offline teaching

Figure 2 Online Teaching vs Offline Teaching

IV. CONCLUSION

This paper attempts to integrate SPOC online teaching and traditional offline teaching, to understand and grasp the development of online education and traditional education as a whole. While still fully appreciating the advantages of BOPPPS-SPOC blending teaching, it is necessary for classroom teaching to return to the origin of learning by pursuing two-way development of student personality and educational collaborative innovation. In the future, education will not be deliberately differentiated between traditional offline and online teaching but instead will require deep integration of the two. Therefore, the focus should be on how to use SPOC to promote the school's education and teaching reforms, improve the quality of curriculum and teaching effectiveness. These problems are worthy of in-depth research.

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Table 2 Application of BOPPPS-SPOC blending teaching in the function chapter of the C language course

Sta	Knowledge Points	Durati	Method	Description
B	Review the content of the	2	Online-A	Briefly summarize the content of the previous lessons and summarize the problems
	Content guide of the lesson	1		Introduce the content outline for the lesson
O	Introduce the main points	1		Summarize the main content to be learned in the class, point out the key and
P	Online test before class	2	Online-J K	Understand the students' mastery over the learnt knowledge
P	Custom function	5	Online-A	Take the calculation of the factorial of 3 as an example to explain the definition.
		5	Offline-F	Through analogical analysis discuss the difference between custom functions and
	Header function	2	Online-A	Explain the composition of the function headers and the meaning of each part
	Function declaration	3	E	Explain the syntactical format of function declarations and the in-depth analysis of
		5	Offline-F	Discuss the role of function declaration
	Defining method functions	2	Online-A	Through analogical analysis explain the two methods of defining functions
		5	Offline-F	Discuss the pros and cons of the two methods of declaring functions
	Function calls	5	Online-A	From the perspective of computational thinking, using "calling" as the key word
		10	Offline-H	Discuss the process of calling nested functions
	Passing values to functions	3	Online-A	Explain the passing values as formal parameters and actual parameters
		10	Offline-H	Analyse the role of formal and actual parameters
	Function return values	2	Online-A	Explain several uses of "return" in the return value
	Nested functions	5	B C D	Analyze the specific process of nested function calls
	Application of functions	5		Implement previous learnt programs with functions and analyze the advantages and
	Q&A	10	Offline-I G	Answer various questions raised by students
P	Online test after class	2	Online-J K	Understand the students' mastery of the content of this section
S	Summary of the lesson	3	Online- A	Help students summarize and condense the content of this lesson
	Preview the content	2		Preview the content of the next class, arrange homeworks and preview materials
	Total time of this lesson			45 minutes online, 45 minutes offline

(Note: method is the combination of A-Z, Online: A-teach B-demo C-case study D-doubt E-self-study J-question K-answer Offline: F-discuss G-sum up H-ask I- answer L-practice N-reply)

Table 3 Evaluation System of BOPPPS-SPOC blending teaching model

Type	Stage	Object	Content	Elements		Implement	Method	Goal
Stage EV	Pre-class	B:	Pre-class preview	Start learning	Learning enthusiasm	Online	Subjective	Guide and urge students to complete pre-class knowledge preparation
		O:	Pre-class preparation	Understand learning	Participation rate of learning		Subjective	
		P:	Pre-class practice	Pass the exercises	Knowledge preparation		Objective comment	
	In-class	P:	Attendance	Number of participants	Attendance rate	Offline	Objective comment	Organize students to participate in discussion and study, and urge students to master knowledge and improve their learning ability
			Teaching process	Study and practice process, cooperative learning, discussion, debate, demonstration, experiment, etc.	Students' participation awareness and ability to participate in classroom learning, knowledge acquisition, emotional investment, and ability improvement		Subjective evaluation	
				P:	Learning effect detection		In-class test	
		S	Knowledge consolidation	Questions in Class			Offline	
	After-class	Acquisition of knowledge	Homework	Internalization, expansion and application of knowledge		Online	Objective comment	Consolidate the knowledge learned in the lesson and promote the transformation of theoretical knowledge into practical actions
		Knowledge application	After-school practice project			Defense	Subjective evaluation	
Comprehensive EV	Teaching Quality	Achievement of the teaching objectives and learning effects	Knowledge mastery and knowledge system construction		Exams, essays, research	Objective evaluation, subjective evaluation	Promote the transformation of theoretical knowledge into practical ability and professionalism	
Concluding	Combine stage evaluation and comprehensive evaluation to give the final evaluation result							

(Note: EV is for "Evaluation")

Table 4 Parts of Teaching effectiveness evaluation system of blending teaching model

Evaluation item	Evaluation standard	W
Mastery of basic knowledge	Students' mastery of the basic knowledge required by the course	0.5
Fusion of old and new knowledge	Students' fusion of existing knowledge and new knowledge	0.5
Basic skills	Be able to use existing basic skills and integrate them into the learning of the new curriculum	0.3
Information tool skills	Under the new learning mode, collect information and learn to use different learning tools	0.3
Learning Resources	Video viewing, document browsing, rich text browsing, in-class quizzes	0.1
Achievement experience	Experience a sense of accomplishment in the learning process	0.4
Learning Design	Develop a phased learning plan and have its own learning mode	0.2
Self-monitoring	Self-observation, supervision, feedback, regulation	0.6
Self-control	Maintain an active, attentive and persistent attitude in the learning process	0.5
Resource sharing	Share valuable learning resources through the Internet or in the classroom	0.1
Discussion Exchange	Participate in discussions, replies and comments in the forum	0.6
Devotion	Actively participate in the learning process	0.3