JOURNAL OF BALTIC SCIENCE EDUCATION
ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

BLENDED LEARNING ON WECHAT PLATFORM-BASED SPOC IN LOWER-SECONDARY SCHOOL SCIENCE TEACHING

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Abstract. *This paper proposes a blended teaching design model on WeChat Platform-based SPOC and carries out an empirical study of its applicability and effectiveness in lower-secondary school science teaching. Participants were from two eighth grade classes with different academic performance, and after conducting the same blended teaching, it was found that pre-class knowledge transmission on the WeChat platform considerably enhanced students' classroom participation, which was also highly related to their improved post-class test scores. The improvement in the performance of the weak groups is more obvious. In addition, backend data from the WeChat platform revealed that the number of resource clicks was significantly higher than the total number of students, indicating that the sharing function of the WeChat platform facilitated the sharing of educational resources. Seven in-service science teachers were also interviewed to qualitatively evaluate and analyze the teaching model from the perspective of in-service teachers. The comprehensive results indicate that the teaching model constructed in this study achieves good results, facilitates the development of students' independent learning ability, and allows for the integration of this blended teaching model into lower-secondary curriculum.*

Keywords: *Blended teaching; Science education; SPOC; Teaching design model; WeChat platform-assisted teaching*

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Introduction

From MOOCs to SPOCs

The concept of Massive Open Online Course (MOOC) was proposed by Dave Cormier and Bryan Alexander in 2008, and the tsunami of MOOC started to sweep across the globe in the late 2012 (Qin & Tan, 2020). In 2013, Tsinghua University in China was the first to conduct research on MOOC courses on the edX platform, but during the rapid development of MOOC, some problems also emerged, such as frustrating completion rates (Jordan, 2015; Yuan & Powell, 2013), high dropout (Zhang et al., 2019), limited student-faculty interaction (Baggaley, 2013; Wise & Cui, 2018), inappropriate cultural background and educational methods (Kang & He, 2018), endangered intellectual property (Berrett, 2013), and deficient pedagogical principles (Qin & Tan, 2020).

In response to these drawbacks of MOOC, Fox proposed to combine MOOC course resources with classroom teaching to form a Small Private Online Course (SPOC) in 2013 (Hashmi, 2013). The researcher believes that MOOC can be used as a supplementary teaching resource, but it cannot completely replace conventional classroom teaching. When it can really improve students' learning efficiency and help teachers impart knowledge, it is a SPOC course (Fox, 2013). SPOC courses are different from MOOC courses and conventional courses, which are a blend of conventional offline teaching and online learning, and a hybrid learning model (Sun, 2019). Online courses mainly refer to the use of MOOC lecture videos, whereas offline teaching refers to the teachers' discussion and research of the issues that arise with students to consolidate and implement knowledge.

In 2013, Harvard University offered three SPOC courses, one of which, "Copyright Law", was offered on the edX platform, in the form of online learning and offline group discussions, followed by a final exam and a certificate for those who passed. This model has been well received and will continue to be delivered in the future. Additionally, Fox at the University of California, Berkeley, offered a SPOC course on "Software Engineering" through the edX platform, which added an automatic scoring function that allowed for timely feedback on online learning (Fox et al., 2014). Meanwhile, Fox also promoted this model, the hybrid teaching model of online learning and offline classroom

https://doi.org/10.33225/jbse/23.22.701

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

integration has achieved excellent teaching results. In contrast to conventional course, SPOC course has its own unique style that is more flexible and incorporates more information technology (Coughlan, 2013).

SPOC courses have also been incorporated into college courses in China. Hua Sun uses a hybrid teaching strategy that combines "Rain Classroom" with SPOC to increase teaching efficiency and level while also deepening students' understanding of course content and forming positive teacher-student interactions (Sun, 2019). In addition, Fox's research revealed that 10% of the users of MOOC courses are teachers, and they integrate the useful parts of the course into the physical classroom through the development and reuse of MOOC video resources (Fox et al., 2014), which is not only the development and use of resources for SPOC courses but also the promotion of the implementation of SPOC courses.

The innovative combination of SPOC online learning and offline classroom learning has realized the comprehensive "deep integration" of information technology and education, which transforms the conventional teaching model of "acquiring knowledge in class and asking questions after class" to "learning both in the classroom and online and online learning assists offline teaching" (Jiang, 2022). The transition from MOOC to SPOC entails a change from online courses to hybrid courses, from shallow learning to deep learning, and from various formats to help students get a deeper comprehension of knowledge and improve their problem-solving abilities. There are also views that, SPOC = Classroom + MOOC (Admiraal et al., 2015; Guo, 2017).

WeChat Platform

With the development of information technology, new education models such as flipped classroom, online courses and smart classroom have risen rapidly, impacting the original teaching practice system. The WeChat platform can carry diversified teaching information, use fragmented times, and go deeper into students' life reality, so it can be utilized as a platform to combine offline classroom and online learning. The blended learning model of the WeChat platform- assisted classroom teaching is also an innovative form of the "Internet+" teaching model.

WeChat Official Account (WOA) is the most frequently visited platform among college students in China (Hou et al., 2017). Functions such as pushing messages and independent interactive communication can be realized on WOA. WOA is an Internet-based product that has web end, mobile phone end and PC end. Users only need to make a simple registration to apply for WOA. Technically, users can follow the WOA account by scanning the QR code of the account, and the administrator of WOA can reply to new followers according to the setting. Teachers can publish new graphic messages through the backend and can also analyze students' reading and learning data.

There are several advantages in applying WOA to education and teaching. Firstly, WeChat has a huge user base, every Chinese college student has a smartphone and a WeChat account and is familiar with using WeChat (Zhang, 2016). WeChat has become one of the emerging social software. Secondly, WeChat has lower operational cost and is easier to combine with Internet technology compared to other teaching software, without developing mobile software, without programming technical foundation, simply by completing the registration of WOA. Thirdly, WeChat is instantaneous, with real-time communication functions and social networking features that allow users to interact with others (Fan et al., 2015). Instant interaction of messages can be achieved by simply installing the WeChat APP and having a mobile network, and managers can also categorize users through the backend, regardless of time and space. Therefore, mobile and micro learning is highly possible for its extensive coverage (Liu & Zhang, 2022; Liu & Jiang, 2015). The fourth is the diversity of information, which can be sent by video, photos, and voice in addition to text to completely push graphic messages. The multiple advantages of WeChat make it have the potential to become a learning medium.

Thus, WOA has won widespread acceptance in China for its free, flexible, interactive and more participatory method to teaching (Tu et al., 2018), but its function of combining with classroom teaching is limited, the functions needed for actual teaching activities are to be further developed. Therefore, other functions need to be added on this basis to build a more comprehensive functional WeChat-assisted teaching platform.

Blended Learning

Blended learning is now considered to be the most effective and popular teaching model adopted by the education institutions (Rasheed et al., 2020) and has received widespread attention from schools and institutions around the world for several reasons. This idea of combining teaching materials with online interventions in an educational setting has proven to be an upgrade from the conventional face-to-face and fully online teaching models, bridging

https://doi.org/10.33225/jbse/23.22.701

the gaps that exist in both of them (Broadbent, 2017; Rasheed et al., 2020). The combination of face-to-face and technology-mediated teaching can lead to shorter distances between teachers and students or between students and students in online transactions, enhancing the interaction between teachers and students (Kamaruzaman & Rouhollah, 2009; Porter et al., 2014; Vaughan, 2007). In addition, compared to face-to-face and fully online teaching, blended learning is more preferred by students due to its flexibility in learning time and space, the breadth and accessibility of learning resources, and its high level of learning autonomy (Ashton & Elliott, 2007; Collopy & Arnold, 2009; Poon, 2012; Reiss & Steffens, 2010).

Several studies have been conducted to compare the effectiveness of blended learning with face-to-face or online learning. Academic success and blended learning are positively correlated, according to several research in higher education (Allen et al., 2007; Bazelais & Doleck, 2018; Bernard et al., 2014; Deschacht & Goeman, 2015; López-Pérez et al., 2011). Blended learning transforms conventional "Duck-stuffing" exam-based education (passive learning that usually involves only acquiring knowledge) into active learning where students actively construct knowledge (Suartama et al., 2019), resulting in a higher level of learning experience and motivation.

In addition, numerous research studies have demonstrated that students have greater satisfaction in blended learning environments, compared to conventional face-to-face and fully online teaching (Castle & Mcguire, 2010; Farley et al., 2011; Martinez-Caro & Campuzano-Bolarin, 2011; Woltering et al., 2009). Blended learning in China has been helpful in solving authentic problems in colleges and vocational education, contributed favorably to students' practical training and significantly increased students' learning satisfaction (Wang et al., 2021). It is predicted that by the end of this century, 80-90% of college and enterprise training courses will adopt blended learning (Kyong-Jee et al., 2005), and that more than 1 billion learners worldwide will improve their skills in this way (Kim et al., 2009).

The classroom teaching sessions in the blended teaching model are more flexible, but it is mostly used in higher education, where students' logical thinking skills are better than the secondary education level, and the effect is more obvious with the blended teaching model.

Research Problem

The WOA platform enables teachers to give students access to top-notch learning resources, monitor their progress, and, as needed, deliver individualized training, all of which increases teacher-student interaction as well as the internalization and depth of knowledge (Wei, 2017; Yan, 2015). Thus, the impact of WeChat as a social software on learning in education has received attention and needs to be explored further (Hou et al., 2021).

However, most of the empirical studies conducted with WOA are biased towards higher education. WOA is mostly used as a supplementary platform for college classroom teaching because it can help students to preview before class, expand their knowledge after class, and enhance their academic success (Shen, 2020). Compared how well students performed and their ability to use higher-order thinking skills, such as critical thinking and problem-solving skills, in the conventional teacher-centered educational model and the WeChat-based flipped classroom teaching approach, scholars found that students' performance and higher-order thinking skills in WeChat-based flipped classroom outperformed their peers taught in conventional classrooms(Liu & Zhang, 2022). Whether the WOA platform can also be used as a supplementary platform for secondary education is a question worthy of consideration.

Additionally, previous studies on blended learning have paid attention to secondary education, which have found that the commognition of the teacher and the student in a series of computer supported one-to-one online tutoring courses experienced three stages: teacher-led commognition process, comparison of commognitive process and student-led commognition process (Lu et al., 2019). Correspondingly, the commognitive responsibility gradually shifted from the teacher to the student (Lu et al., 2020), and the proportion of student-led collaborative problem solving increased (Lu et al., 2022). Such a blended course based on Constructivism makes students become increasingly agile in communication and cognitive interaction, and their cognitive level and class participation are gradually improved, which serves to cultivate critical thinking skills.

Through searching the Chinese Full-text Journal Database with "WeChat Official Account" as the keyword, it was found that the research on WeChat platform-assisted classroom teaching model mainly focused on two aspects: college classroom and theoretical research. Besides, there is less research on SPOC courses using WeChat platform, so the teaching function of the WeChat platform was further developed, and a blended teaching course was designed through the combination of SPOC courses and WeChat platform, to study the design and implementation of WeChat platform-assisted lower-secondary school science classroom teaching based on SPOC.

The hypothesis of this study was that integrating a blended teaching model with a lower-secondary school

https://doi.org/10.33225/jbse/23.22.701

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

science curriculum in a SPOC environment based on the WeChat platform, results in students exhibiting superior performance. Three questions were addressed as follows:

1. Compared with conventional teaching, whether the model of SPOC-based WeChat-assisted teaching is more conducive to improving students' academic performance, and whether the improvement range of students at different levels is consistent?
2. Compared with conventional teaching, whether the model of SPOC-based WeChat-assisted teaching is more conducive to enhancing students' classroom participation and learning motivation?
3. Whether the model of SPOC-based WeChat-assisted teaching is effective and applicable in lower-secondary school science teaching?

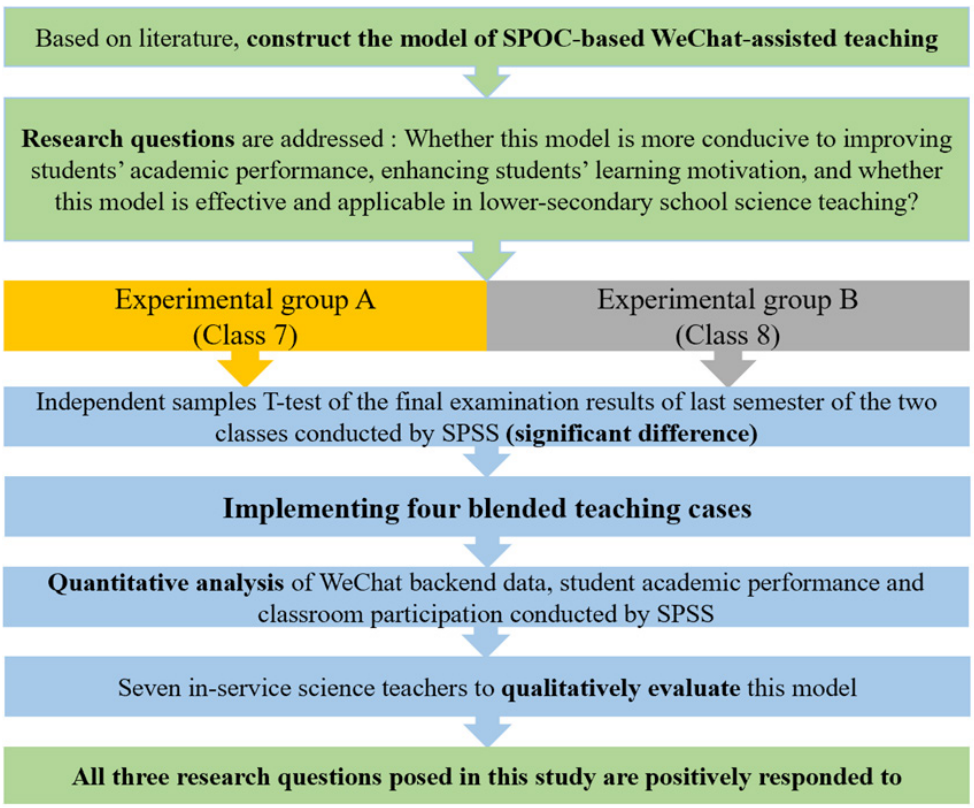
Research Methodology

General Background

This study mainly adopted the action research method. This study constructed a new blended learning model based on literature, that is, the SPOC-based WeChat-assisted teaching model. In response to the three research questions raised above, this study implemented four cases for teaching practice intervention in two eighth-grade classes in the first semester of the 2021 academic year. This study describes the specific process by taking the "Shui De Zu Cheng (Composition of Water)" as an example. Qualitative and quantitative methods were used to analyze the experimental data. SPSS software was used to conduct quantitative analysis on WeChat backend data, students' academic achievements, classroom participation and other data. Additionally, seven in-service science teachers were interviewed to qualitatively evaluate the model. Finally, through the comprehensive analysis of qualitative and quantitative data, consider whether the three research questions have received positive responses.

The research design and process of this study are shown in Figure 1.

Figure 1
Research Design and Process



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Participants

Participants were from two eighth grade classes of a lower-secondary school in Hangzhou, China, Class 7 (25 students) and Class 8 (37 students), with different academic performance. None of the participants had any previous experience in SPOC-related learning activities. These two classes are randomly selected from the eighth grade of the lower-secondary school. Table 1 displays the final examination results of the two classes in the last semester. The average scores of the two classes differed by about 38 points, with Class 8 performing better academically than Class 7, while the standard deviation of the two classes was not much different, indicating that the score distribution of the two classes was relatively uniform.

Table 1
Academic Performance before the Implementation of the Teaching Model

	AVE	SD	SEM
Class 7	57.92	22.73	4.55
Class 8	95.59	22.05	3.62

The results of the independent samples T-test of the final exam scores of the two classes were conducted by SPSS, and the results of the test are shown in Table 2. The data in the table shows that the significance (two-sided) value is less than .001, and there is a significant difference in the achievement of two classes, so the two levels of classes are chosen as experimental classes for the study.

Table 2
Difference Test between Final Exam Results of Class 7 and Class 8 (Independent Sample T-test)

		Levene's equal variance test		t-test for equality of mean values			
		F	*p*	*df*	*p (two-sided)*	*MD*	*SE*
Final exam results of the last semester	Adopt equal variance	.01	.92	60	p <.001	37.67	5.77
	Equal variance is not used			50.58	p <.001	37.67	5.81

Construction of SPOC-based WeChat-assisted Teaching Platform

Application for WeChat Official Account

As a platform to support classroom teaching, the "I want to learn science" WeChat Official Account was first applied for to implement the teaching practice. Students can follow the WOA by scanning the WeChat QR code of "I want to learn science". To register for the WOA, you only need to log in to the official registration page of the WOA to apply for a subscription number (individuals can only apply for a subscription number), which can be used after the auditing is completed.

Function development of WOA

The basic functions of WOA can realize the delivery of graphic messages and videos but it cannot provide other functions required for classroom teaching. Thus, this study developed WOA twice to build a fully functional platform suitable for classroom teaching.

https://doi.org/10.33225/jbse/23.22.701

ISSN 1648–3898 /Print/
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(1) Basic Functions

The basic functions of the WOA include publishing graphic messages, uploading teaching PPTs and videos to the material management in the backend, and then publishing the resources through new graphic messages. After teachers create a new graphic message in the backend and send it to the group, students can immediately receive the message and prepare to learn.

(2) Expanding Functions

The functions of WOA are limited and insufficient to fulfill all the requirements for supporting classroom teaching, including online test and message board. Therefore, the functions are developed with the help of third-party development software. Due to the complicated operation of other development backend software, this study chose the relatively simple development software to realize the functions of online test, column diversification and message board. The functions of the WeChat platform are all set up to serve classroom teaching. After building the WOA according to different functions, the specific resources are uploaded by different teachers of different courses in accordance with their own classes. Teachers only need to upload the resources after setting up this WeChat platform, without programming. For teachers, the operation is simple and will not take up too much teaching time, and they can check the students' task completion results through the backend so that teachers can keep abreast of students' knowledge mastery.

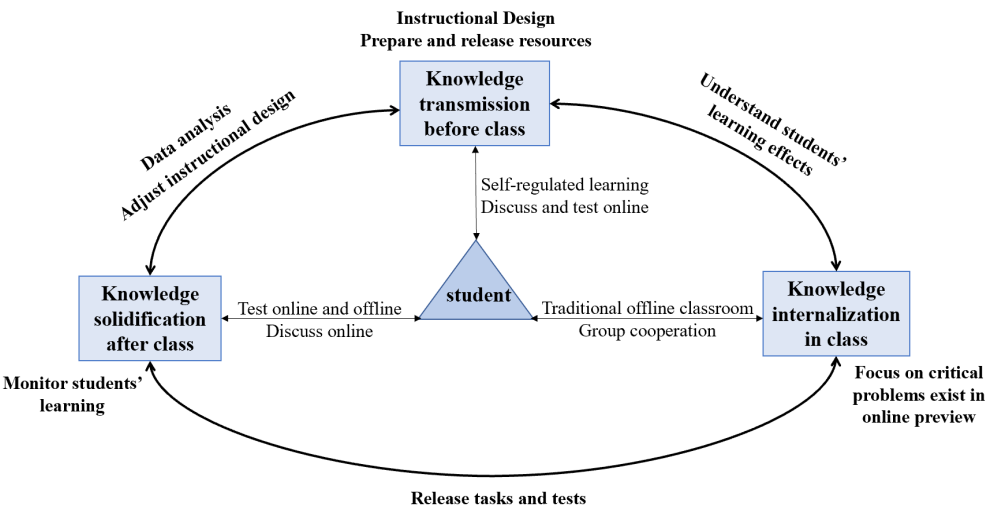
After the function development through the association with the third-party platform, the teaching functions that can be realized by WOA can be roughly divided into four parts: resource acquisition (such as teaching PPTs, videos, supplementary exercises, knowledge expansion), student display (such as student work display, student voting), communication evaluation (such as message board, exchange Q&A), and online test (including pre-class preview test and post-class consolidation test).

Research Procedure

The teaching design of SPOC-based WeChat-assisted teaching mainly includes three parts: before class, during class and after class (Figure 2). The teacher releases resources through WOA before class, and students receive information to preview in advance. During class, the teacher focuses on solving critical problems that exist in students' online preview, and after class, the teacher publishes knowledge expansion on the WeChat platform to broaden students' horizons, and they can also consolidate and enhance students' knowledge mastery through online test function of WeChat platform.

The students are the main body in this whole process, and every step is based on students' needs. The powerful function of the WeChat platform supports students' independent learning while facilitating meaningful learning to occur. As students learn, they can also forward and share with other students, discuss on the WeChat platform, and teachers can participate in the process by giving guidance to students and responding to their questions. In this process, the teacher and students form a community through the WeChat platform and classroom teaching.

Figure 2
SPOC-based WeChat-assisted Teaching Model



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a) Knowledge transmission before class. The teacher releases relevant learning resources through the WeChat platform before class, students then receive information through smartphone WeChat software and study under the supervision of their parents. During the learning process, students can pause for reflection at any time, and can also ask questions on the platform at any time to communicate with their classmates and teachers. Teachers even can publish resources at different levels for different types of students, which requires teachers to develop teaching resources carefully before releasing them, either by recording videos of important and difficult points, or by recombining online resources, mainly based on students' needs for the secondary development of resources. Teachers can also issue pre-class task lists to help students explore knowledge with tasks.
b) Knowledge internalization in class. Through the knowledge transmission before class, students already have a certain knowledge base. The in-class knowledge internalization session is mainly based on classroom teaching, and the content is the most important part of knowledge acquisition. The task list before class is also a preparation for the in-class teaching. By focusing on students' learning dynamics through pre-class backend analysis, teachers can analyze the common problems of students and based on this, teachers can rearrange classroom activities to solve students' problems, and improve students' classroom concentration and motivation.
c) Knowledge solidification after class. After class, the teacher can release the exercises on the WeChat platform, and while students answer the questions online, the teacher can understand the difficult problems encountered by students in the exercises through the backend. For timely consolidation of knowledge, teachers and students can also communicate through the WeChat platform. At the same time, teachers can improve the teaching process through students' online learning performance and evaluate students in various aspects.

A Practical Research in Science of Lower-Secondary School

The model of SPOC-based WeChat-assisted teaching constructed in the research is divided into three parts: knowledge transmission before class, knowledge internalization in class and knowledge solidification after class. The following is an example of the case "Shui De Zu Cheng (Composition of Water)", and the implementation of each part is introduced in detail.

Knowledge transmission before class

The pre-class preparation of "Shui De Zu Cheng (Composition of Water)" was mainly divided into two parts, the first part was the preparation and development of resources, and the second part was the editing and uploading of resources. The development of pre-class resources includes videos, pictures, and audio, etc. For "Shui De Zu Cheng (Composition of Water)", the pre-class resources were mainly videos and task lists. The task list is for students to learn and explore knowledge purposefully, but since the task list is text in Word format, it cannot be directly posted on the WOA, so it must be converted into pictures first and then uploaded to the backend material management for publishing graphic messages. Preliminary processing is also needed for video uploading. Note that videos larger than 20M need to be uploaded to Tencent Video for audit first or processed through software, and after processing, they also need to be uploaded to the backend material management of WOA first and the graphic messages can be released only passed Tencent's audit.

The operation video about the electrolysis experiment of water was released because the main points of this lesson are the electrolysis experiment of water and the decomposition reaction of water (composition of water). Releasing the experiment video before class is the basis for the teacher's demonstration experiment in class. Of course, the content of the video is not necessarily experimental video but can also be an explanation or an extension of the knowledge. Therefore, in addition to uploading the experimental videos, two short videos based on knowledge points were also uploaded, reviewing three variations in the physical properties and chemical properties of water, so that the students' memory of their knowledge reserve could be awakened for better teaching during classroom teaching.

The videos, task lists and other materials were edited and uploaded to the backend of the WOA, the teacher consolidated all the resources and released them for all the students of Class 7 and Class 8 to receive the resources for learning in the WeChat. After learning, students could interact through the WeChat platform so that teachers can comprehend the problems students encountered before class and focus on solving them in class.

https://doi.org/10.33225/jbse/23.22.701

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Knowledge internalization in class

The in-class session is mainly focused on classroom teaching, with emphasis on the combination of learning resources released online. By transferring knowledge before the class, the knowledge transmission in the class can be more fluent, the key points can be more prominent, and the depth of knowledge can be deepened in the class.

In the classroom teaching of "Shui De Zu Cheng (Composition of Water)", the demonstration experiment of water electrolysis, the generalization for the experimental phenomenon and the extension of the experimental conclusion were focused on. Guided by the experiment video and task list before class, students could easily conclude that the electrolysis of water gives oxygen at the positive pole, hydrogen at the negative pole, and oxygen and hydrogen are produced under the condition of electricity, so the classroom teaching could focus on the extension of the experimental conclusion.

Because the composition of water molecules is very abstract, the composition of water molecules was also the focus of classroom teaching, from the experimental conclusion that water is composed of hydrogen (element) and oxygen (element), extended to the abstract conclusion that in chemical reactions, molecules can be divided into atoms, while atoms can no longer be divided. Additionally, the discussion of students' questions before class revealed that the most difficult point of knowledge for students was the composition of water molecules, from macroscopic to the microscopic level. Therefore, in the classroom lecture, microscopic animation was integrated into the teaching activities, turning microscopic into intuitive, solving the students' understanding difficulties with intuitive feeling and internalizing knowledge.

Knowledge solidification after class

The after-class session of the "Shui De Zu Cheng (Composition of Water)" was divided into three parts. The first part was the preparation of PPT resources, each PPT must also be processed into pictures first before being uploaded to the material management of the WOA. Through the new graphic message to publish PPT-related information, the PPT used in the class will be uploaded to the WOA following the lesson, allowing students to supplement the notes not recorded in time during class. For students to find this information quickly, the "PPT" secondary menu was set up under the primary menu "Micro. Resources", students can click the "PPT" menu button to jump to receive this graphic message. For previous learning resources, the keyword reply matching was set up, when responding to keywords, the corresponding learning resources will pop up, of course, students can also check the history of the message to find the previous resources.

The second part was the after-class online test. Online tests not only provide students with a method to consolidate their knowledge but also give teachers a platform to understand the status of students' homework in real time. The function of online test is implemented in the third-party backend, a "Micro. Test" menu was set up in the WOA, each after-class practices are linked here, students can click on this menu to receive the practices that pop up. The time limit for completing exercises can be set. Each practice question is input in the backend with the correct option hidden so that the platform can score and evaluate immediately after the student completes the online test. Teachers can check the completion of students' online tests in the backend and make statistics. Additionally, teachers can also note students' names and categorize them according to their academic status.

By setting the keyword "Calculate", students can access the answer page by replying to the keyword "Calculate". When designing the questions on the editing page, teachers need to input each option and the score for each question separately. The question types can be single-choice and multiple-choice, and the rest of the questions can be sent to the WOA in the form of pictures. Once the questions are uploaded, they can be posted. The interface is simple, and students do not need to switch pages, which is more in line with the cognitive characteristics of students.

Online tests can be set not only after class but also released before class. Following the preview, students are given pre-class tests, allowing teachers to easily comprehend the problems that students encountered before class and focus on solving them in class to improve the efficiency of teaching. Online tests lighten the teacher's burden and maximize class time.

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The third part is the exchange and Q&A. On the one hand, due to the fact that students have limited time to study in the school and need to study many subjects, so they may not always have time to communicate face-to-face with teachers in the school, therefore the WOA provides an opportunity to communicate with teachers on a one-to-one basis. A message board was set up on the WOA, where students can leave messages to their teachers. On the other hand, students can ask questions directly on the platform when they encounter problems in online learning or have questions about the classroom learning, the teacher can reply directly in the backend. A "Micro. Communication" menu and two sub-menus under it - Question Exchange and Message Board- were also set up. By clicking on the message board, students can enter the message board by replying "I want to leave a message" according to the prompt.

Students can discuss questions here, expressing each person's insights and opinions, turning it into a learning discussion area where they can engage in interesting informal learning after school. Of course, one-on-one communication between students and teachers is also possible to answer questions directly on the WOA.

Adopting online, offline, and online approaches for the pre-class, in-class, and post-class sessions respectively is a type of blended teaching. Blended teaching refers to a multifaceted hybrid teaching model, the essence of which refers to the interconnection between online and offline, in-class and out-of-class and interdisciplinary, it is a kind of teaching that combines online teaching with conventional teaching, which is defined as "online and offline" (Wu, 2022). After-class knowledge solidification is very important, German psychologist Ebbinghaus put forward the concept of a forgetting curve, human forgetting for new things is gradual, and the forgetting speed is the fastest at the beginning of learning. Therefore, using WOA to assist students in consolidating knowledge and improving the efficiency of knowledge mastery when learning new knowledge.

Data Analysis

Using a combination of quantitative and qualitative research methods, students' acceptance of the blended teaching model and their mastery of knowledge can be understood, through quantitative analysis of WeChat backend data, student academic performance, and their changes in classroom performance behavior. Data analysis was conducted by SPSS software to evaluate the design and implementation of the SPOC-based WeChat-assisted teaching based on the results of correlation tests between students' classroom performance and academic performance. Interviews were also conducted with seven in-service science teachers to qualitatively evaluate and analyze the teaching model from the perspective of in-service teachers, assess the feasibility of the model, and make suggestions for subsequent reforms.

Through a comprehensive analysis, the main teaching design model is proposed to realize the integrated application of this blended teaching in a course that develops students' independent learning skills.

Research Results

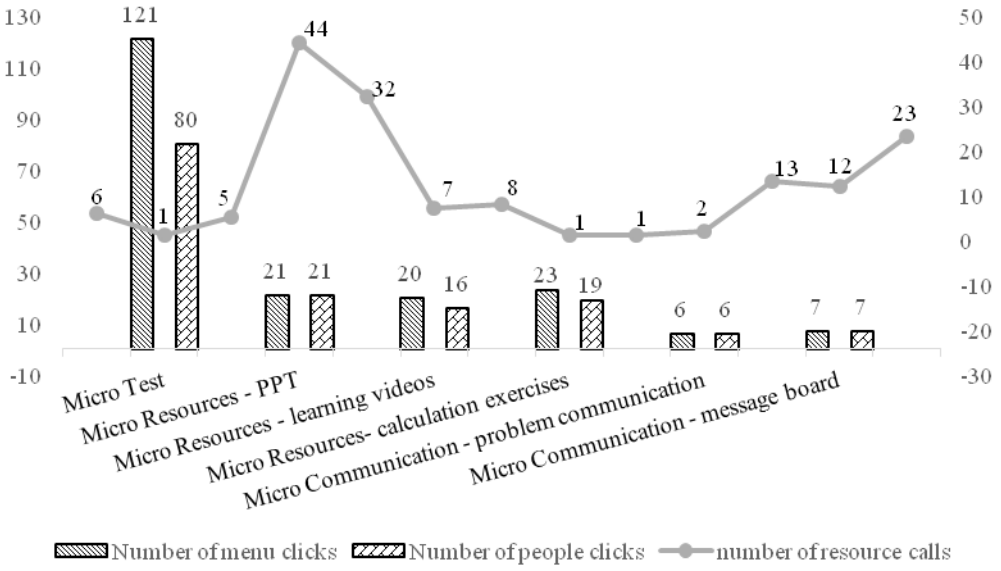
Based on WeChat Backend Data Analysis

(1) The function of data statistics in the backend of WOA was used to count the backend click data of "Shui De Zu Cheng (Composition of Water)" learning resources, as shown in Figure 3.

https://doi.org/10.33225/jbse/23.22.701

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Figure 3
Statistics of Menu Clicks and Resource Calls in the Backend of WOA



Learning resources including PPTs, experimental videos, and online tests were released on September 29 (at the black arrow) and sent to 62 students and 7 teachers of Class 7 and Class 8. The figure shows that the peak period of students' clicks of learning resources was ushered in at the beginning of the holiday on September 29 and September 30, and in the days when the holiday was about to end on October 6, 7 and 8. The total number of resource calls was 143, indicating that students had repeated learning on the WeChat platform, which provides students with a platform and personalized learning space that can be repeatedly learned anytime, anywhere. In comparison, the frequency of using the WeChat platform increased significantly after the "I want to learn science" WOA was put into use on September 29, indicating that the The WeChat platform can enhance students' motivation and interest in learning.

(2) The data analysis function of the WOA backend was used to count the click volume data of the hierarchical menu of "I want to learn science" WOA, as shown in Figure 3.

It can be seen that the first-level menu "Micro. Test" received the most clicks, with 121 clicks during this period, and 1.51 clicks per capita, demonstrating that students attach great importance to online tests. The number of online tests far exceeds the number of students in the class, but each account can only take one online test within the specified time, so it is certain that some students shared the learning content with their friends or other learners, and other learners who did not follow the WOA also studied and tested by clicking the shared information. This shows that the sharing function of WeChat promotes the shareability of resources and expands the audience of resources, fully reflecting the feature that Internet learning is not limited by time and space. Secondly, "Micro. Resources", the secondary menu of which had a high click rate of calculation exercises, learning videos and PPT menus, with the number of clicks per capita reaching more than 1.00, because these resources can help students to learn outside of class.

Analysis of Academic Performance

The performance of two classes at two levels before and after the implementation of the model was compared, which showed that after the implementation of the two cases through SPOC-based WeChat-assisted teaching, students actively conducted online tests on the WeChat platform to consolidate knowledge in a timely manner. Subsequently, the following tests of these contents were conducted in two classes, and the statistics of the two tests are shown in Figure 4. As can be seen from the figure, the overall distribution of scores after the implementation of these two cases is above the final exam results. This indicates that after the online learning sessions before

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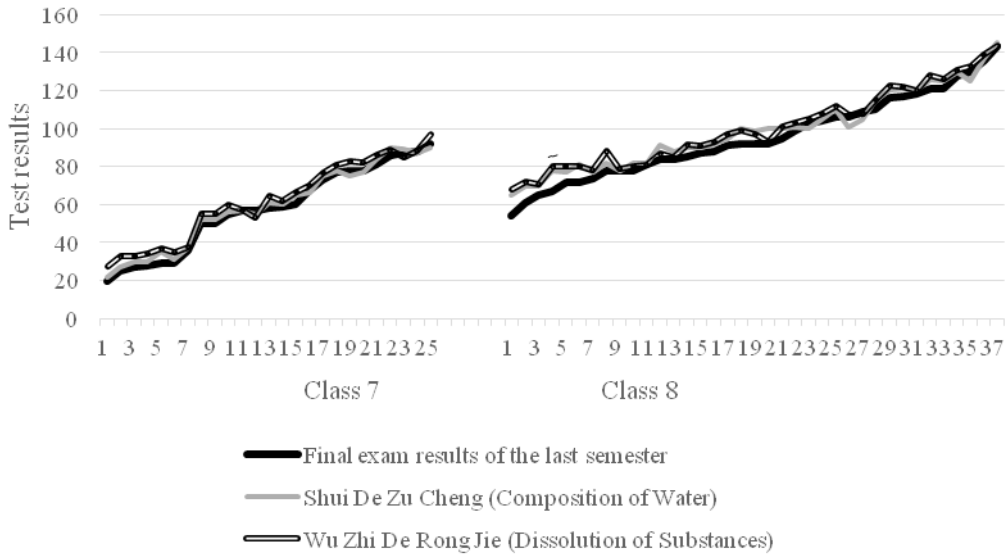
and after class, the students' academic performance improved to a certain extent, especially for the students in the lower range. It may be that the students were more interested in the content of the class after the pre-class learning, and could concentrate more on the class, so the class was more attractive to students, which can effectively improve their learning efficiency.

Figure 4
Test Results before and after the Implementation of SPOC-based WeChat-assisted Teaching Model



In addition, the test scores of Class 7 and Class 8 were statistically and analytically compared by class (Table 3), it was found that the average scores of both tests in both classes increased compared to the final scores, and the standard deviation decreased. This indicates that the scores of both classes have improved and the dispersion of the scores has decreased.

Table 3
Analysis of Academic Performance and Classroom Participation

		Class 7	Class 8
Final exam results of the last semester	AVE	57.92	95.59
	SD	22.73	22.05
	SEM	4.55	3.62
Shui De Zu Cheng (Composition of Water)	AVE	59.24	99.27
	SD	21.95	20.22
	SEM	4.39	3.32
Wu Zhi De Rong Jie (Dissolution of Substances)	AVE	61.92	100.43
	SD	21.45	20.61
	SEM	4.29	3.39
Classroom participation	Before implementation	11	21
	Shui De Zu Cheng (Composition of Water)	26	28
	Wu Zhi De Rong Jie (Dissolution of Substances)	34	31

https://doi.org/10.33225/jbse/23.22.701

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Analysis of Classroom Participation

As indicated in Table 3, the number of classroom participation of students was also counted in two different levels of classes before and after the implementation of the SPOC-based WeChat-assisted teaching model. The comparison reveals that after the pre-class knowledge transmission session, the students' enthusiasm for participating in class greatly rose, especially for Class 7, which had a lower overall level, and the students' class participation increased rapidly. Through the pre-class knowledge transmission, students studied the teaching content in advance and were able to respond positively to the teacher's questions in class, while the teacher established more connections with the pre-class knowledge in class to form knowledge transmission and promote students' understanding of knowledge.

The Relationship between Academic Performances and Classroom Participation

The number of classroom participants in the two classes was counted before and after the implementation of the two cases. The amount of change in the number of classroom participation was obtained after averaging the number of classroom participation in the two classes before and after implementing the cases respectively, and the correlation between the test scores and the number of classroom participation was analyzed using SPSS software.

Table 4
Correlation Analysis between the Change of Academic Performance and the Change of Students' Participation in Class 7

		Change value of test result of "Composition of water"	Change value of test result of "Dissolution of substances"	Changes in the number of students participating in the class
Change value of test result of "Composition of water"	*PCCs*	1	.99**	.47*
	p (two sided)		p <.0001	.016
	N	25	25	25
Change value of test result of "Dissolution of substances"	*PCCs*	.99**	1	.46*
	p (two sided)	p <.0001		.020
	N	25	25	25
Changes in the number of students participating in the class	*PCCs*	.47*	.46*	1
	p (two sided)	.016	.020	
	N	25	25	25

**. Correlation is significant at the .01 level.
*. Correlation is significant at the .05 level.

As can be seen from Table 4, the Pearson correlation coefficient between the test scores of "Shui De Zu Cheng (Composition of Water)" and the amount of change in the number of times classroom participation is .47, with a two-tailed uncorrelated test value of .016, thus rejecting the hypothesis that they are not correlated. The Pearson correlation coefficient between the test scores of "Wu Zhi De Rong Jie (Dissolution of Substances)" and the amount of change in the number of times classroom participation is .46, with a significance (two-sided) test value of .020. From these two data, a significant correlation is obtained at both the .01 and .05 levels. In other words, the more students participate in class, the higher their test scores will be. However, it remains to be further examined whether the improvement of students' academic performance is all due to the result of implementing SPOC-based WeChat-assisted teaching, but it is certain that the implementation of SPOC-based WeChat-assisted teaching helps students' classroom participation and their mastery of what they have learned.

https://doi.org/10.33225/jbse/23.22.701

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Evaluation and Analysis of In-service Teachers

During the implementation of the two cases, seven in-service science teachers of the same grade were invited to be interviewed afterwards. The WeChat platform was deemed a good platform for supporting the classroom by all seven of the teachers. The integration of the core thinking of the SPSS curriculum with the WeChat platform is a good teaching method to use in the classroom. There are a variety of online learning courses that are emerging and are of great interest to students. For the teacher, the pre-class knowledge transfer session is the first preparation for the textbook content, and the implementation of the in-class knowledge internalization session after understanding the learning situation is another preparation. After the second preparation, classroom teaching was more targeted, and students' interest in learning and classroom attraction was enhanced.

However, two teachers noted that the preparation of pre-class resources and post-class online tests would take up extra time for teachers, because teachers in lower-secondary school are extremely busy, especially head teachers. On the other side, however, the online tests and micro-communication sections of the WeChat platform reduced teachers' time for correcting assignments and communication. Overall, it did not occupy too much for teachers. Furthermore, two teachers suggested that the application of this teaching method could be more flexible and not all contents are suitable for after-class or before-class sessions. In fact, not all content has to follow this model, the WeChat platform is just an auxiliary platform. What materials need to be put on the WeChat platform to assist in teaching are determined by the teaching design of the teacher in charge of the class. It just serves as a tool to supplement classroom teaching, and this model is flexible and changeable.

Several other teachers proposed that this is a new teaching method that supplements conventional teaching and is full of attraction and novelty. After the pre-class session, the classroom lessons were also more targeted. Especially for new teachers, this model is equivalent to secondary preparation. Following the pre-lesson session, the students' learning situation is initially understood, and the secondary preparation improves classroom efficiency, the post-class session promotes the consolidation of students' knowledge while also serving as a time for teachers to reflect on teaching, which is conducive to the growth of new teachers.

In addition, teachers also suggested that more functions could continue to be developed in depth on the WOA, such as the student display module. In some highly interactive content, students can be invited to prepare the display content, giving them an opportunity to demonstrate their value, and also reflecting the main role of students. Make teaching activities more flexible and let students become the masters of the classroom.

Discussion

In this study, SPOC-based WeChat-assisted teaching was proposed as a new blended teaching model with the aim of studying the role of this teaching model in lower-secondary school science courses. After four cases of blended teaching using this model, all three research questions posed in this study were positively responded to.

Regarding question 1, the changes in academic performance before and after the implementation of the SPOC-based WeChat-assisted teaching model in these two classes were compared, and it was found that the academic performance of both classes was higher than the final exam results of the previous semester, indicating that this blended teaching model has an important role in promoting students' academic performance. In addition, from the analysis of the improvement range of academic performance, it can be concluded that this blended teaching model is more effective in promoting the academic development of students at the lower level of the class.

The literature shows that MOOC provides a platform for students to learn independently and breaks the limitation of teaching time and space. However, it is open to students on a national or even global scale and the teaching principles are defective (Qin & Tan, 2020). It is suggested that students should learn in the SPOC environment rather than in the MOOC environment (Fox, 2013). SPOC teaching can deal with high-quality teaching resources differently according to the differences of student bases, so as to meet the needs of different students' learning objectives and provide different levels of learning content (Chen, 2022; Qiu, 2022). This blended teaching model provides more personalized choices for students to learn specific courses and teaching methods are more targeted. However, Fox et al.'s research on SPOC still focuses on higher education. This study not only combines the WeChat platform with SPOC but also emphasizes the applicability and effectiveness of SPOC in secondary education.

The results of the study were similar to those of Shen, indicating that the introduction of social media-WeChat-as an auxiliary tool to classroom teaching can achieve student-centered teaching and improve students' ability to actively learn (Shen, 2020). However, the study only demonstrated that students who actively participated in

https://doi.org/10.33225/jbse/23.22.701

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

WeChat interactions exhibited higher final grades. In contrast, this study compared the positive effects of the blended teaching model in all three aspects: longitudinal time level, cross-sectional student base level, and the relationship between classroom participation and academic performance. It pointed out that the SPOC-based WeChat-assisted teaching model could improve students' academic performance, and the higher the classroom participation the better the academic performance, and that the improvement in academic performance was different for different levels of students.

Regarding question 2, by analyzing the changes in students' classroom participation in both classes before and after receiving the blended teaching model, this study shows that the SPOC-based WeChat-assisted classroom teaching model can promote students' classroom participation and enhance their learning motivation. In addition, the WeChat backend data reveals that the frequency of students using the WeChat platform to assist their learning increased, and more importantly, students used the sharing function of WeChat to share their learning content with other classes, all of which indicate that the WeChat platform can enhance students' motivation to learn and improve their learning enthusiasm.

As proved in the literature, students were inattentive to what was being said in the lecture for 40% of the time (Meyers & Jones, 2010). However, interactive teaching involving high-level interaction increases students' involvement that students are devoted to learning to facilitate their engagement (Paul et al., 2014). Under the blended teaching model, students can enhance the transformation and absorption of knowledge through more exchanges and discussions with teachers and classmates, and effectively improve students' enthusiasm for learning (McLaughlin et al., 2014). Different from other studies on MOOC and blended learning, the SPOC-based WeChat-assisted classroom teaching model designed in this study is proposed on the basis of the secondary development of WOA in conjunction with third-party platforms, which can better meet the actual teaching needs.

Sun described a blended teaching model, which combines the "Rain Classroom" and SPOC, forming a good atmosphere for interaction between teachers and students, and deepening students' understanding of knowledge (Sun, 2019). However, the "Rain Classroom" platform used in this study is a teaching platform that is not used frequently. Students need to register using WeChat and become familiar with the operation of this platform for a period of time. Different from the "Rain Classroom" used by Sun, this research directly uses the WeChat platform. As the social platform with the highest average daily visits in China, almost all Chinese people have a WeChat account and can skillfully use it, which avoids the disadvantages of students' registration process and unfamiliarity with the platform and reduces the technical difficulty and time cost. The SPOC-based WeChat-assisted classroom teaching model makes up for the high dropout rate of MOOC (Zhang et al., 2019) and the limited interaction between teachers and students (Baggaley, 2013; Wise & Cui, 2018).

Regarding question 3, based on the previous analysis of students' academic performance, classroom participation and WeChat backend data, it is confirmed that the model is applicable and effective to a certain extent for lower-secondary school students. Through the analysis of the interview content of seven in-service science teachers, from the perspective of in-service teachers, it also reflects the tendency to maintain a positive and supportive attitude towards the blended teaching model and points out that after using the teaching model to prepare lessons for the second time and track students' learning situation, teachers can have a clearer grasp of learning situation and teaching can be more targeted. Of course, this model can also be further improved and developed.

In addition, another important finding of this study is similar to the results of Tong et al. With the help of the WeChat platform, the frequency and complexity of students' classroom participation have increased (Tong et al., 2022). However, this study also analyzes the correlation between students' test scores and classroom participation and finds that there is a positive correlation between them. The more students participate in the class, the higher their test scores will be.

Conclusions and Implications

This research combined SPOC and WeChat platform to develop a new blended teaching model. Firstly, the development trend of SPOC, the blended teaching model and the application of the WeChat platform in teaching were analyzed. Secondly, the SPOC based WeChat-assisted classroom teaching model was developed, and the blended teaching process of science in lower-secondary school based on this model was introduced. According to the feedback results of qualitative and quantitative data, the following conclusions were drawn:

(1) The SPOC-based WeChat-assisted classroom teaching model proposed in this study is applicable and effective in lower-secondary school science curriculum.

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(2) This teaching model divides the teaching process into pre-class, in-class and post-class stages, so that teaching is no longer limited to the classroom, and the sustainability of teaching and the enthusiasm of students for learning have been improved.

(3) This research combines SPOC and WeChat platform, innovates the classroom teaching model, and covers the deficiencies of conventional teaching. Online teaching and offline teaching are organized at the same time to make the course more reasonable, facilitate the change of course teaching methods, and help students become the main body of classroom teaching. Under this teaching mode, the feedback of learning resources and various links is improved, and excellent teaching results have been achieved in lower-secondary school science teaching.

Based on these, several suggestions and improvement strategies for the use of this model have been proposed for reference of front-line teachers only:

(1) Interface optimization. Lower-secondary school students lack focus on learning. The choice of fonts, pictures and materials in the learning interface should be moderate. Optimizing the WeChat learning interface and improving the attractiveness of materials can stimulate students' desire to continue learning and ensure high-quality learning.

(2) Perfect communication system. A more perfect communication system can be further developed and improved to achieve a faster and more effective circulation of learning resources among WeChat friends.

(3) Build a "fragmented" learning environment. Make full use of the "fragmented" learning advantages of WeChat to build a learning space suitable for the WeChat platform, while paying attention to the coherence and systematicness of disciplines.

(4) Establish a mechanism combining multiple evaluation methods. Under this blended teaching model, multiple evaluation can be realized, including timely evaluation of teachers, automatic scoring of tests, students' learning performance indirectly reflected by WeChat backend data, and mutual evaluation between students.

(5) Personalization and diversity need to be integrated. Students with different foundations can obtain learning resources that meet their personalized needs on the learning platform to enhance the pertinence of teaching. In addition, teachers can make full use of the advantages of the platform to release diversified learning resources to stimulate students' learning motivation.

The innovation of this study is mainly summarized in the following two aspects. First of all, for the research audience, this study transferred the SPOC teaching model to secondary education, expanding the research object of the SPOC teaching model; additionally, in terms of platform development, this research chose the WeChat platform as the online platform for blended teaching. This platform is widely accepted in China because of its interactive, attractive, adaptable, portable, sustainable, and more participatory teaching methods. And combined with the characteristics of SPOC courses, the function of the WeChat platform has been re-developed in combination with the third-party platform, so that it can meet more teaching needs.

Limitations and Suggestions for Further Research

However, there are still some limitations in the current study. Firstly, this research is in line with the new concept of the current teaching reform, but due to irresistible reality reasons, this research only involves 62 students from two classes of Grade 8 in a lower-secondary school in Hangzhou, China. There is no large-scale analysis of this blended teaching method in a wider scope. The problems and suggestions identified are only applicable to this group of participants. Therefore, further research will be carried out later, including more lower-secondary schools, learning stages and participants, to draw general conclusions on common problems. Secondly, this study focuses on the applicability of mobile learning methods, mainly using SPSS software for data analysis, and does not involve other scientific measurement tools. The use of a more standardized international scale to evaluate the role of this teaching model in other aspects is a problem that needs to be explored in the future. Finally, the research on the SPOC based WeChat assisted classroom teaching model has just started, and the model proposed in this study is just a rudiment, with the hope that it can be further improved through follow-up research, continuous practice, and gradually establish relevant theoretical and practical guidance to provide a theoretical basis for the implementation and application of WeChat and blended learning in basic education.

Declaration of Interest

The authors declare no competing interest.

https://doi.org/10.33225/jbse/23.22.701

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

References

Admiraal, W., Huisman, B., & Pilli, O. (2015). Assessment in massive open online courses. *Electronic Journal of e-Learning, 13*, 207-216. https://files.eric.ed.gov/fulltext/EJ1062116.pdf

Allen, I. E., Seaman, J., & Garrett, R. (2007). *Blending in: The extent and promise of blended education in the United States*. https://files.eric.ed.gov/fulltext/ED529930.pdf

Ashton, J., & Elliott, R. (2007). Juggling the balls—Study, work, family and play: student perspectives on flexible and blended heutagogy. *European Early Childhood Education Research Journal, 15*(2), 167-181. https://doi.org/10.1080/13502930701321378

Baggaley, J. (2013). MOOC rampant. *Distance Education, 34*(3), 368-378. https://doi.org/10.1080/01587919.2013.835768

Bazelais, P., & Doleck, T. (2018). Blended learning and traditional learning: A comparative study of college mechanics courses. *Education and Information Technologies, 23*(6), 2889-2900. https://doi.org/10.1007/s10639-018-9748-9

Bernard, R. M., Borokhovski, E., Schmid, R. F., Tamim, R. M., & Abrami, P. C. (2014). A meta-analysis of blended learning and technology use in higher education: From the general to the applied. *Journal of Computing in Higher Education, 26*(1), 87-122. https://doi.org/10.1007/s12528-013-9077-3

Berrett, D. (2013). Debate over MOOCs reaches Harvard. *The Chronicle of Higher Education*. https://www.chronicle.com/article/debate-over-moocs-reaches-harvard/

Broadbent, J. (2017). Comparing online and blended learner's self-regulated learning strategies and academic performance. *The Internet and Higher Education, 33*, 24-32. https://doi.org/10.1016/j.iheduc.2017.01.004

Castle, S. R., & Mcguire, C. (2010). An analysis of student self-assessment of online, blended, and face-to-face learning environments: Implications for sustainable education delivery. *International Education Studies, 3*(3), 36-40. https://doi.org/10.5539/ies.v3n3p36

Chen, J. (2022). Effectiveness of blended learning to develop learner autonomy in a Chinese university translation course. *Education and Information Technologies*. https://doi.org/10.1007/s10639-022-11125-1

Collopy, R. M. B., & Arnold, J. M. (2009). To blend or not to blend: Online-only and blended learning environments. *Teacher Education, 18*(2), 85-101. https://www.xueshufan.com/publication/2577508772

Coughlan, S. (2013). Harvard plans to boldly go with 'SPOCs'. *BBC News*. http://www.bbc.co.uk/news/business-24166247

Deschacht, N., & Goeman, K. (2015). The effect of blended learning on course persistence and performance of adult learners: A difference-in-differences analysis. *Computers & Education, 87*, 83-89. https://doi.org/10.1016/j.compedu.2015.03.020

Fan, W., Yan, M., Kai, L., & Qiu, B. (2015). A practical study in the flipped classroom based on WeChat under environment of mobile learning. *Open Education Research, 21*(3), 90-97. http://en.cnki.com.cn/Article_en/CJFDTOTAL-JFJJ201503012.htm

Farley, A., Jain, A., & Thomson, D. (2011). Blended learning in finance: Comparing student perceptions of lectures, tutorials and online learning environments across different year levels*. *Economic Papers: A journal of applied economics and policy, 30*(1), 99-108. https://doi.org/10.1111/j.1759-3441.2010.00094.x

Fox, A. (2013). From MOOCs to SPOCs. *Communications of The ACM, 56*(12), 38-40. https://doi.org/10.1145/2535918

Fox, A., Patterson, D. A., Ilson, R., Joseph, S., Walcott-Justice, K., & Williams, R. (2014). Software engineering curriculum technology transfer: Lessons learned from MOOCs and SPOCs. *Electrical Engineering and Computer Sciences*. https://www2.eecs.berkeley.edu/Pubs/TechRpts/2014/EECS-2014-17.pdf

Guo, P. (2017). MOOC and SPOC, which one is better? *Eurasia Journal of Mathematics Science and Technology Education, 13*(8), 5961-5967. https://doi.org/10.12973/eurasia.2017.01044a

Hashmi, A. H. (2013). HarvardX set to launch second "SPOC" (Small, Private, Online Course). *Distance Education Report*. https://www.thecrimson.com/article/2013/9/17/kennedy-school-spoc-edx/

Hou, J., Ndasauka, Y., Jiang, Y., Ye, Z., Wang, Y., Yang, L., Li, X., Zhang, Y., Pang, L., Kong, Y., Xu, F., & Zhang, X. (2017). Excessive use of WeChat, social interaction and locus of control among college students in China. *Plos One, 12*(8). https://doi.org/10.1371/journal.pone.0183633

Hou, R., Han, S., Wang, K., & Zhang, C. (2021). To WeChat or to more chat during learning? The relationship between WeChat and learning from the perspective of university students. *Education and Information Technologies, 26*(2), 1813-1832. https://doi.org/10.1007/s10639-020-10338-6

Jiang, L. (2022). Factors influencing EFL teachers' implementation of SPOC-based blended learning in higher vocational colleges in China: A study based on grounded theory. *Interactive Learning Environments*, 1-20. https://doi.org/10.1080/10494820.2022.2100428

Jordan, K. (2015). MOOC completion rates: The data. *MOOC Project*, 1-2. http://www.katyjordan.com/MOOCproject.html

Kamaruzaman, J., & Rouhollah, K. (2009). Preliminary study on the role of social presence in blended learning environment in higher education. *International Education Studies, 2*(4), 79-83. https://files.eric.ed.gov/fulltext/EJ1065767.pdf

Kang, Z., & He, L. (2018). Construction and practice of SPOC teaching mode based on MOOC. *International Journal of Emerging Technologies in Learning, 13*(12), 35-49. https://doi.org/10.3991/ijet.v13i12.9702

Kim, K.-J., Bonk, C. J., & Teng, Y.-T. (2009). The present state and future trends of blended learning in workplace learning settings across five countries. *Asia Pacific Education Review, 10*(3), 299-308. https://doi.org/10.1007/s12564-009-9031-2

Kyong-Jee, Kim, Curtis, J., Bonk, TingTing, & Zeng. (2005). Surveying the future of workplace e-learning: The rise of blending, interactivity, and authentic learning. *eLearn, 2005*(6), 2-2. https://doi.org/10.1145/1073198.1073202

Liu, D., & Zhang, H. (2022). Improving students' higher order thinking skills and achievement using WeChat

https://doi.org/10.33225/jbse/23.22.701

based flipped classroom in higher education. *Education and Information Technologies, 27*(5), 7281-7302. https://doi.org/10.1007/s10639-022-10922-y

Liu, H., & Jiang, X. (2015). A design and teaching practice of college English teaching based on WeChat platform. *Foreign Language and Literature*, *4*, 138-143.

López-Pérez, M. V., Pérez-López, M. C., & Rodríguez-Ariza, L. (2011). Blended learning in higher education: Students' perceptions and their relation to outcomes. *Computers & Education, 56*(3), 818-826. https://doi.org/https://doi.org/10.1016/j.compedu.2010.10.023

Lu, J., Tao, Y., Xu, J., & Stephens, M. (2020). Commognitive responsibility shift and its visualizing in computer-supported one-to-one tutoring. *Interactive Learning Environments*. https://doi.org/10.1080/10494820.2020.1777167

Lu, J., Tuo, P., Feng, R., Stephens, M., Zhang, M., & Shen, Z. (2022). Visualizing commognitive responsibility shift in collaborative problem-solving during computer-supported one-to-one math tutoring. *Frontiers in Psychology*. https://www.frontiersin.org/articles/10.3389/fpsyg.2022.815625/full

Lu, J., Zhang, X., & Stephens, M. (2019). Visualizing the commognitive processes in computer-supported one-to-one tutoring. *Interactive Learning Environments, 27*(5-6), 645-654. https://doi.org/10.1080/10494820.2019.1610452

Martinez-Caro, E., & Campuzano-Bolarin, F. (2011). Factors affecting students' satisfaction in engineering disciplines: traditional vs. blended approaches. *European Journal of Engineering Education, 36*(5), 473-483. https://doi.org/10.1080/03043797.2011.619647

McLaughlin, J. E., Roth, M. T., Glatt, D. M., Gharkholonarehe, N., Davidson, C. A., Griffin, L. M., Esserman, D. A., & Mumper, R. J. (2014). The flipped classroom: A course redesign to foster learning and engagement in a health professions school. *Academic Medicine, 89*(2), 236-243. https://doi.org/10.1097/ACM.0000000000000086

Meyers, C., & Jones, T. B. (2010). Promoting active learning. Strategies for the college classroom. *Biochemistry & Molecular Biology Education*. https://doi.org/10.1016/0307-4412(94)90198-8

Paul, Baepler, J., D., Walker, Michelle, & Driessen. (2014). It's not about seat time: Blending, flipping, and efficiency in active learning classrooms - ScienceDirect. *Computers & Education, 78*(Sep.), 227-236. https://doi.org/10.1016/j.compedu.2014.06.006

Poon, J. (2012). Use of blended learning to enhance the student learning experience and engagement in property education. *Property Management, 30*(2), 129-156. https://doi.org/10.1108/02637471211213398

Porter, W. W., Graham, C. R., Spring, K. A., & Welch, K. R. (2014). Blended learning in higher education: Institutional adoption and implementation. *Computers & Education, 75*, 185-195. https://doi.org/10.1016/j.compedu.2014.02.011

Qin, M. X., & Tan, X. (2020). Examining a SPOC experiment in a foundational course: design, creation and implementation. *Interactive Learning Environments*, 1-18. https://doi.org/10.1080/10494820.2020.1722710

Qiu, X. (2022). Blended teaching mode of higher vocational english based on MOOC plus SPOC. *Wireless Communications & Mobile Computing, 2022*. https://doi.org/10.1155/2022/9320161

Rasheed, R. A., Kamsin, A., & Abdullah, N. A. (2020). Challenges in the online component of blended learning: A systematic review. *Computers & Education, 144*. https://doi.org/10.1016/j.compedu.2019.103701

Reiss, M., & Steffens, D. (2010). Hybrid toolboxes: Conceptual and empirical analysis of blending patterns in application of hybrid media. *Ukio Technologinis ir Ekonominis Vystymas, 16*(2), 305-326. https://doi.org/10.3846/tede.2010.20

Shen, J. (2020). Introduction of social media to aid active-learning in medical teaching. *Interactive Learning Environments*. https://doi.org/10.1080/10494820.2020.1766508

Suartama, I. K., Setyosari, P., Sulthoni, & Ulfa, S. (2019). Development of an instructional design model for mobile blended learning in higher education. *International Journal of Emerging Technologies in Learning, 14*(16), 4-22. https://doi.org/10.3991/ijet.v14i16.10633

Sun, H. (2019). A SPOC teaching mode of college english translation based on "Rain Classroom" *International Journal of Emerging Technologies in Learning, 14*(17), 182-193. https://doi.org/10.3991/ijet.v14i17.11206

Tong, P., Yin, Z., & Tsung, L. (2022). Student engagement and authentic language use on WeChat for learning Chinese as a foreign language. *Computer Assisted Language Learning*. https://doi.org/10.1080/09588221.2022.2052906

Tu, S., Yan, X., Jie, K., Ying, M., & Huang, C. (2018). WeChat: An applicable and flexible social app software for mobile teaching. *Biochemistry and Molecular Biology Education, 46*(5), 555-560. https://doi.org/10.1002/bmb.21170

Vaughan, N. (2007). Perspectives on blended learning in higher education. *International Journal on E-learning, 6*(1), p.81-94. https://www.redalyc.org/pdf/706/70643085002.pdf

Wang, L., Huang, Y., & Omar, M. K. (2021). Analysis of blended learning model application using text mining method. *International Journal of Emerging Technologies in Learning, 16*(1), 172-187. https://doi.org/10.3991/ijet.v16i01.19823

Wei, Z. F. (2017). Construction of higher vocational english teaching model based on WeChat. *Campus English*(41), 56-57. https://kns.cnki.net/kcms/detail/detail.aspx?FileName=XYYY201741049&DbName=CJFN2017

Wise, A. F., & Cui, Y. (2018). Learning communities in the crowd: Characteristics of content related interactions and social relationships in MOOC discussion forums. *Computers & Education, 122*, 221-242. https://doi.org/10.1016/j.compedu.2018.03.021

Woltering, V., Herrler, A., Spitzer, K., & Spreckelsen, C. (2009). Blended learning positively affects students' satisfaction and the role of the tutor in the problem-based learning process: results of a mixed-method evaluation. *Advances in Health Sciences Education, 14*(5), 725-738. https://doi.org/10.1007/s10459-009-9154-6

Wu, C. (2022). Effect of online and offline blended teaching of college english based on data mining algorithm. *Journal of Information & Knowledge Management, 21*. https://doi.org/10.1142/S0219649222400238

Yan, J. F. (2015). A review of the researches on WeChat. *International Conference on Social Science and Technology Educantion*. https://www.docin.com/p-1732142144.html

https://doi.org/10.33225/jbse/23.22.701

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Yuan, L., & Powell, S. (2013). *MOOCs and open education: Implications for higher education*. https://doi.org/10.13140/2.1.5072.8320
Zhang, L. (2016). Research on the practice of flipped class mode based on the platform of WeChat. *Journal of US-China Public Administration, 13*(5), 358-366. https://doi.org/10.17265/1548-6591/2016.05.005
Zhang, X. M., Yu, J. Y., Yang, Y., Feng, C. P., Lyu, J., & Xu, S. L. (2019). A flipped classroom method based on a small private online course in physiology. *Advances in Physiology Education, 43*(3), 345-349. https://doi.org/10.1152/advan.00143.2018

Received: *November 01, 2022* Revised: *May 30, 2023* Accepted: *June 10, 2023*

Cite as: Xu, T., Xu, J., Xu, X., & Lu, J. (2023). Blended learning on WeChat platform-based SPOC in lower-secondary school science teaching. *Journal of Baltic Science Education*, *22*(4), 701-718. https://doi.org/10.33225/jbse/23.22.701

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