Embedded Selforganizing Systems

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The Design, Practice and Effects of a SPOC

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***Abstract*—The 2022 "Frontier of Educational Technology" summer school was held by the Department of Educational Technology, Graduate School of Education, Peking University from July 4th 2022 to July 8th 2022. In order to ensure the learning quality, a small private online course was designed for the first time. A series of learning activities such as ice-breaking trip, expert lectures, group discussions, and group presentation were carried out with the help of the course management system, live broadcast platform and social media groups. We analyzed the data recorded by the course management system and found that more than half of the students participated in all learning activities, and the final completion rate of the summer school was as high as 89.86%. An online questionnaire was used to examine students' subjective responses to the pedagogy and course performance. The results showed that the average score of almost all the questions in the questionnaire was greater than 4.3 points (out of 5.0), indicating that most students are satisfied or very satisfied with this pedagogy. Suggestions for improvement and future expectations are put forward, and can provide a reference for the full-online SPOC practice and research that are being widely carried out around the world.**

Keywords—SPOC; Online learning; Live classroom; Instructional design; Summer school

I. INTRODUCTION

At the beginning of 2020, with the prevalence of Covid-19, both higher education and the k-12 sector have attempted full-scale online learning as the Ministry of Education of the People's Republic of China has called for actions to "fulfill our teaching responsibilities without meeting in person by utilizing our online platforms" in order to ensure the safety of our faculty and students and reach our teaching goals. As coronavirus epidemic continues to spread around the world, offline class around the world has been forced to stop. According to UNESCO statistics [1], up to April 1st 2020, the number of countries affected by the epidemic reached 194, and 91.3% of students were unable to attend offline class; as of June 26th 2020, 116 countries had stopped offline class which affected 1.087 billion students. Based on this background, online learning has become one of the important means to carry out normal pedagogical practices during the epidemic and even post-epidemic era.

Before the outbreak of the covid-19, online education had already quietly emerged. In 2012, The surge of massive open online courses (MOOCs) in the United States swept China's online education in 2013 [2]. The large-scale application of MOOCs break the time and space limitation of learning and bring new hope for the realization of educational equity. Various online learning platforms sprang up exuberantly, and online courses and learning resources have been greatly enriched. However, this quantitative expansion was accompanied by a qualitative crisis [2]. Since MOOCs have no prerequisite or size limits, a large number of students with different knowledge backgrounds and learning abilities flood into the same course, resulting in a high registration rate and a low completion rate [4]. To solve this problem, a kind of Small but refined course type named Small Private Online Course (SPOC) was born. The terms "small" and "private" in SPOC are compared to the terms "massive" and "open" in MOOCs. "small" means that the number of students in SPOC is generally controlled between dozens and hundreds. "private" means that there are restricted entry conditions for participating in SPOC, so only applicants who meet the conditions can become enrolled students.

At present, pedagogical practices based on SPOC can be roughly divided into two categories. One is the course for internal students of the school, which usually adopts blended learning mode combining online learning and traditional face-to-face learning. For example, Prof. Anant Agarwal from San José State University in California carried out SPOC for students on campus by using the online course "analog circuits" created by MIT on EdX platform[5]. Before class, students watched videos on the EdX platform and completed the online pre-test. In class, Prof. Anant Agarwal organized students to work together to solve problems encountered in the pre-test. After class, students took a post-test on what they learned through the online platform. Finally, by applying the SPOC, the percentage of students receiving C or above increased from 59% to 91% [5]. In China, during the period of COVID-19 suspension, some scholars also carried out similar SPOC based on flipped classroom in primary and secondary schools. Through the t-test, it was found that there were significant differences in the scores of students in the experimental group and the control group in the post-test, which verified the learning effect of SPOC [6]. Another is to

select a certain number of students from the global applicants to participate in SPOC according to the entry conditions. Enrolled students are usually required to participate in a set of online activities to earn a certificate of completion, such as watching lecture videos, studying assigned materials, completing online quizzes, and participating in online discussions. For example, Harvard University opened three courses based on SPOC worldwide in 2013. Applicants were required to fill in the necessary demographic information and write a short paper to prove their knowledge level during application. Enrolled students were required to participate in at least 8 hours of online courses per week, 80 minutes of online group seminars per week, and finally a 3-hour online examination to obtain the final certificate of completion [7]. At the same time, SPOC have been actively carried out in UC Berkeley, Binghamton University and etc., which has obtained good response. It can be seen that SPOC is very suitable for short-term training, academic forum, summer school and other scenarios carried out for groups with common learning interests inside and outside the school. Peking University's postgraduate innovative training program, launched in 2009, also falls under the above category.

Open university's high-quality courses to public is conducive to better meet the public's demand for high-quality educational resources [8]. Peking University's postgraduate innovative training program is one of the important measures to realize the above vision. The "Frontier of Educational Technology" summer school organized by the Department of Educational Technology has been continuously funded by this program. The main enrollment targets of the summer school are young teachers, master's and doctoral students, even a small number of outstanding senior undergraduates, teachers in primary and secondary schools, and personnel from relevant enterprises who have a strong interest in educational technology research. Relying on the teaching staff of Peking University and invited well-known experts, the summer school has a great impact both domestic and overseas. Statistically, more than 3,500 people have attended it and it won the first prize of Peking University Teaching Achievement Award in 2017 and the first prize of Beijing Higher Education Outstanding Achievement Award in 2018.

Since the outbreak of COVID-19 in 2020, on the one hand, it is difficult for summer schools to gather students from all over the world on campus for offline learning. On the other hand, MOOCs are not only expensive to produce but also difficult to ensure the learning quality. Therefore, the full online SPOC has been explored and applied in this summer school.

II. PREPARE FOR ORGANIZATION AND ENROLLMENT

In December 2021, the Graduate School of Peking University issued a notice about applying for the 2022 "Postgraduate Innovative Training Program". As usual, the Department of Educational Technology, School of Education, Peking University actively applied for the 2022 "Frontier of Educational Technology" Summer School. According to the application plan, the department set up a working group to take charge of the summer school, consisting of two teachers and four students.

On June 2nd, 2022, the summer school "Frontier of Educational Technology" enrollment guidelines were confirmed by working group and released through WeChat tweet to expand the enrollment scope. In the tweet, in order to simplify the enrollment process, the link and QR code of application form were set up. Applicants could click the link or scanned QR code to fill in the name, gender, date of birth, school, department, grade, ID card number, mobile phone number and other personal information, and uploaded the copy of ID card, personal resume, recommendation letter and other supporting materials.

By midnight of June 15th, a total of 153 people signed up. It was found that the vast majority of applicants are graduate students, doctoral students and young teachers in universities in China, a small number of them are middle school teachers, staff of enterprises and public institutions. Due to budget and network bandwidth constraints, the final decision was to enroll about 45 percent of the initial applicants in the summer school. During the selection, it was basically guaranteed that at least one person from each school is enrolled. If a school had a large number of applicants, they would be sorted according to the correlation between the materials submitted and the summer school enrollment conditions, which reflects the "private" characteristic of SPOC. If there was little difference in correlation, they were randomly selected. On June 22th, the list of enrolled students was announced. Among the 153 applicants, 69 of them were enrolled, which is in line with the "Small" of SPOC.

Applicants were also informed of the enrollment results by email. Then enrolled students were imported into the course management system (CMS), with their full names spelled in Chinese phonetic alphabets as their user names and initial passwords. The users were divided into eight groups for computer-supported collaborative learning.

Since June 23th, enrolled students had been joining the WeChat notification group of the summer school by scanning the QR code in the email, and logging into the CMS to upload their profile picture, edit their personal information, and change their personal account password according to the requirements. 4 teaching assistants compared the photocopy of the ID card submitted by the enrolled students with the picture uploaded in the system, so as to verify the identity of every students. At the same time, in order to better organize, each teaching assistant was responsible for two groups respectively and established their own small WeChat groups. All notices and activities related to the summer school were published in the CMS, WeChat notification group and 8 small groups at the same time to ensure that every student were able to get the latest news in time.

III. INSTRUCTIONAL DESIGN

As shown in Table I. , the teaching activities planned for this summer school include: ice-breaking trip, expert lectures, group discussions, group presentation, etc.

TABLE I. 2022 PEKING UNIVERSITY "FRONTIER OF EDUCATIONAL TECHNOLOGY" SUMMER SCHOOL ACTIVITY SCHEDULE

Activity	Activity requirements	number of times
ice-breaking trip	Each student post self-introduction in their group discussion area in the CMS.	1
expert lectures	Students can click the corresponding link in the CMS to access the online conference room. During the lecture, each student needs to take a screenshot of his/her real	10

Activity	Activity requirements	number of times
	profile picture, the speaker's profile picture and the contents of the PPT and upload it with at least 100 words in the text area to the CMS.	
group discussion	Students can directly enter the group discussion room by clicking the corresponding link in the CMS to have online discussion on hot topics in the field of educational technology, and finally organize the group discussion results into document and upload it on the CMS within the prescribed time.	2
group presentation	An academic debate on the topic of "Education and technology" will be hold in each group, then representative of each group collect the views to report to all the students and teachers. The debriefing time should not exceed 15 minutes for each group, with an additional 5 minutes to answer questions from other groups.	1

A. Course management system and technical support

We designed and developed a CMS called "CSIEC" based on the Moodle to guarantee the operation of full online SPOC. It's address is http://class.csiec.com/course/view.php?id=11, and the homepage is shown in Fig. 1.

Fig. 1. Homepage of the "CSIEC".

All activities can be completed on the CMS. Students only need to log into the website and complete the corresponding learning activities in the prescribed time according to the chronological order. For example, after logging into the CMS for the first time, students can click on " ice-breaking trip" and create topics in the discussion board to introduce themselves to others; The week-long expert lectures (including the final group presentation) use the same online meeting link, so students can click on the same link every day to enter the conference room; Before expert lectures, teaching assistants upload slides and other relevant learning resources one day in advance, so students can download them from the website; In addition, as shown in Fig. 2, after the expert lectures, students are supposed to upload the screenshots with the lecture slides and their own face photos, as well as their comments on the lecture; When conducting group discussion activities, as shown in Fig. 3, each group member can only click the link of their own group to join the discussion. After the discussion, group members need to make posts and comments in the discussion board.

Fig. 2. Requirements of "expert lectures".

Fig. 3. Requirements of " group discussion".

Compared with the traditional face-to-face offline learning, the CMS has some unique advantages for personalized learning. Specifically, it can automatically record the track of each student's browsing course resources and participating in course activities, and allocate the corresponding next step activities and resources according to each student's previous activity progress and achievement. Such advantages make it particularly suitable for remote online learning, such as this summer school. Under the premise of limited funds and human resources like teachers and teaching assistants, it helps teachers to realize effective management of students and guarantee learning quality.

B. Certificate of Completion

For the guarantee of students' learning effect, a combining of formative evaluation and summative evaluation was adopted. Only students who meet all the following 3 requirements can receive a certificate of completion:

(1) As of 12:00 noon on July 8th , class attendance rate > 40% (4 times).

(2) As of 12:00 noon on July 8th, the group discussion attendance rate was 100% (2 times).

(3) Each group completed the group presentation on the afternoon of July 8th.

IV. LECTURE EXPERTS AND CONTENT

All the online lectures of this summer school were carried out by 8 experts, including 1 expert from the Education Technology and Resource Development Center of the Ministry of Education of China, 1 expert from the overseas university, 5 experts from other universities and research institutions in China, and 1 expert from our own department. In addition, two outstanding doctoral students graduated from our department were invited to share their research. many hot topics in the field of educational technology were covered in the lectures, such as learning science, artificial intelligence and education, and educational informatization, which basically reflect the latest research results of these scholars.

V. TEACHING IMPLEMENTATION PROCESS

Before the summer school, we communicated with lecture experts several times through email, WeChat or other channels to determine the lecture schedules and requirements. We uploaded the lecture topics, abstract, references and slides on the CMS the day before the lecture.

The opening ceremony of the summer school was held online at 9 a.m. on July 4th 2022. From July 4th 2022 to July 8th 2022, 10 lectures, 2 group discussions and 1 group presentation went on as scheduled. Log data of all the activities was tracked and recorded in CMS .

At the end of the summer school on June 8th 2022, teaching assistants exported study logs from the CMS to calculate the engagement of each student in various activities during the summer school. Only students who meet the completion requirements will receive certificates and corresponding credits. Finally, a total of 62 students graduated successfully.

VI. THE LEARNING EFFECT

A. Descriptive Statistics of students

A quasi-experiment wasn't conducted to measure the learning outcome including gained knowledge and skills, because human resources were not enough to monitor students during a written examination online. But, the activity data recorded in the CMS were exported for statistical analysis of students' engagement. In the meanwhile, to measure course performance of the summer school and obtain students' feelings and experience, students were required to fill in the online questionnaire on the CMS. A total of 60 valid questionnaires were received. First of all, from the perspective of gender ratio, due to the disciplinary characteristics of the education, male students accounted for 22.58% and female students accounted for 77.42%. From the perspective of educational background distribution, the majority were master's students, accounting for 33.87%, undergraduate, doctoral and non-school students accounted for 22.58%, 17.74% and 25.81% respectively. From the perspective of students' background, educational technology accounted for more than 61.29%, and information science and information management both accounted for 3.23%. In addition, although the SPOC has a short history, 88.71% of the students said that they had experience in SPOC learning before.

B. Curriculum engagement in statistics

Up to 12:00 on July 8th, the engagement of students in various activities is shown in 0. More than half of the students participated in all the activities, and the number of students finished the two group discussions and one group presentation accounted for 89.86% (Table II) of the total number of enrolled students. Therefore, compared with the MOOC, SPOC can better guarantee students' engagement in activities, so as to improve the final completion rate.

TABLE II. STATISTICS OF ENGAGEMENT IN COURSE ACTIVITIES

Activities completion	The number of students	The ratio of the number of students to the number of enrolled students
10 expert lectures	44	63.77%
9 expert lectures	16	23.19%
8 expert lectures	1	1.45%
5 expert lectures	2	2.90%
2 group discussions	62	89.86%
1 group presentation	62	89.86%
The requirements for certification	62	89.86%

C. Students' subjective evaluation of the course learning experience

The questionnaire was divided into two parts, namely, the students' subjective evaluation of course learning experience and the evaluation of course performance. The five-point Likert scale designed by Chen et al [8]. is used to evaluate the course learning experience, which is respectively measured from three aspects: students' subjective response, teaching effect evaluation and students' satisfaction, among which answer 1 is the lowest score and 5 is the highest score. The statistical results of students' answers are shown in Table III. As can be seen from the table, students' evaluation of the three dimensions are relatively positive. Except for the 10th item, the average score of almost all the items is more than 4.3, indicating that most students think that this way of learning experience is good. It is worth noting that the second item of the dimension of learning satisfaction, namely, "I think there is little difference in the learning effect between online learning and face-to-face teaching", has a mean of 3.85 and a standard deviation of 1.09, indicating that students have different opinions on this point of view and are in a relatively neutral attitude. In the follow-up open-ended questions, we conducted a more in-depth investigation on this phenomenon.

TABLE III. EVALUATION OF COURSE LEARNING EXPERIENCE

No.	Category	Item	Mean	Standard deviation
1	course learning experience	Bad 1→ Excellent 5	4.75	0.50
2		Difficulty 1→ Easy 5	4.27	0.65
3		Frustrating 1 → Satisfying 5	4.75	0.47
4		Function insufficient 1 → Function sufficient 5	4.75	0.47
5		Dull 1→ Exciting 5	4.53	0.69
6		Rigid 1→ Flexible 5	4.55	0.72
7	teaching effect evaluation	Little improvement 1→ Much gain 5	4.72	0.52
8		Not worth mentioning 1 → Worthy of recommendation 5	4.88	0.37
9	students' satisfaction	I am satisfied with the results of online learning.	4.72	0.49
10		I don't think there is much difference between online learning and face-to-face learning.	3.85	1.09

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5		Dull 1→ Exciting 5	4.53	0.69
6		Rigid 1→ Flexible 5	4.55	0.72
11		I hope I can continue to use this way to study in the future, and I will recommend it to others.	4.68	0.57

D. Course performance analysis

Similarly, the relevant scale of user experience of website designed by Gosling et al. [9] was improved to form 14 evaluation statements of course performance, and 5-point Likert scale was used to design questions about course performance in the questionnaire, in which answer 1 was the lowest score and 5 was the highest score. Firstly, as shown in Table IV. , KMO analysis and Bartlett test were conducted on the questionnaire data, and it is found that the value of KMO was 0.842, which was higher than 0.8, indicating that the basic conditions for factor analysis are met. At the same time, the P-value of Bartlett's sphericity test is much less than 0.05, indicating that it is very suitable for this analysis.

TABLE IV. KMO AND BARTLETT'S TEST

KMO	0.84	
Bartlet t's test	***The approximate chi-square***	*507.34*
	df	91
	P value	0.00001

The principal component factor analysis was carried out with the method of orthogonal rotation for these 14 questions, and the results are shown in Table V. . Taking factor loading coefficient greater than 0.4 as the extraction criterion, three factors are obtained. Factor 1, factor 2 and factor 3 are named as course design performance, system performance and course content performance respectively. The course design performance mainly includes the course block strategy, the course activity development form, the course schedule, etc. The system performance mainly includes the system platform interface friendliness, stability, interactivity, etc. The course content performance mainly includes the main content of the course, the content of learning materials, the viewpoint from communication, etc.

Finally, as shown in Table VI. , the mean and standard deviation of the 14 questions of course performance were statistically analyzed, and it is found that the mean of all items in the three dimensions of course design performance, system performance and course content performance are all greater than 4.4, and the standard deviation is no more than 0.8. It indicates that students' evaluation of the instructional design, the CMS and the curriculum content of this summer school is biased to be positive. Moreover, the results are consistent with the subjective evaluation of students' learning experience analyzed above. Therefore, it can be inferred that the high satisfaction of students may come from three aspects. The first is the curriculum design based on connectivism.

TABLE V. PRINCIPAL COMPONENT ANALYSIS RESULTS

Item	F			D	N
	F1	*F2*	*F3*		
I can have a good interaction with my classmates and get friendship and support.	0.68	0.23	0.52	0.78	course design performance
I receive satisfactory support on technical and business issues related to the course.	0.86	0.25	0.20	0.84	
Various channels such as instant messaging and discussion boards are used for interaction.	0.66	0.33	0.22	0.60	
The online group discussion help me grasp the course content.	0.54	0.49	0.48	0.79	
The intra-group review in the seminar enable us to experience not only collaboration and democracy, but also the efficiency and convenience of the platform.	0.88	0.10	0.18	0.81	
The sharing and mutual comments in the discussion encourage me to study hard and gain a lot.	0.88	0.02	0.26	0.85	
I think online learning is very necessary.	-0.12	0.78	0.19	0.69	system performance
The CMS is user-friendly.	0.16	0.81	-0.07	0.69	
The CMS is stable and reliable.	0.33	0.70	0.13	0.62	
It is easy to complete the activities on the CMS.	0.41	0.61	0.27	0.61	
I can have a good interaction with the teacher and solve my doubts.	0.26	0.10	0.63	0.47	course content performance
Lectures by well-known international and domestic experts have opened my eyes and diversified my views.	0.23	0.42	0.43	0.42	
The slides uploaded on the CMS can help me understand the class content better.	0.10	0.04	0.81	0.67	
Class sign-in prompts me to attend class on time.	0.44	0.20	0.60	0.58	

[a.] F represents Factor load factor. Blue values in the cells indicate the clustering factors

[b.] D represents degree of commonality (common factor variance)

[c.] N represents Naming of factors

Online group discussion increases students' comprehensive understanding of knowledge, and academic debate within the group allows students to create new viewpoints and ideas in arguments. The second is the multi-channel messaging and integrated CMS. Students can obtain the latest notices through WeChat groups, CMS, etc. At the same time, all learning activities are integrated in the CMS, so students only need to log in to the CMS, and all the learning activities of this summer school can be accessed and completed in the specified time. The third is high-quality course content. The learning content with the latest research outcomes from experts in the field of educational technology broadens students' horizons. Among them, the mean value of

the dimension "CMS" is lower than that of the other two dimensions, which may be caused by the insufficient number of concurrent users, slow response, and inhumane interface.

TABLE VI. MEAN AND STANDARD DEVIATION STATISTICS OF 14 ITEMS OF COURSE PERFORMANCE

NO.	Dimension	Item	Mean	Standard deviation
1	course design performance	The sharing and mutual comments in the discussion encourage me to study hard and gain a lot.	4.78	0.56
2		The online group discussion help me grasp the course content.	4.75	0.60
3		The intra-group review in the seminar enable us to experience not only collaboration and democracy, but also the efficiency and convenience of the platform.	4.72	0.61
4		Various channels such as instant messaging and discussion boards are used for interaction.	4.87	0.34
5		I receive satisfactory support on technical and business issues related to the course.	4.78	0.45
6		I can have a good interaction with my classmates and get friendship and support.	4.78	0.49
7	system performance	I think online learning is very necessary.	4.88	0.32
8		The CMS is user-friendly.	4.4	0.69
9		The CMS is stable and reliable.	4.33	0.77
10		It is easy to complete the activities on the CMS.	4.57	0.67
11	course content performance	Lectures by well-known international and domestic experts have opened my eyes and diversified my views.	4.87	0.34
12		The PPT uploaded on the CMS can help me understand the class content better.	4.80	0.44
13		Class sign-in prompts me to attend class on time.	4.70	0.56
14		I can have a good interaction with the teacher and solve my doubts.	4.68	0.57

E. Analysis of Open Question Answering

The value of 10th item "I don't think there is much difference between online learning and face-to-face learning." in TABLE III. shows that although most students are satisfied with this full-online SPOC, they still think that there are some differences between online learning and face-to-face learning. Therefore, we also collected students' attitudes and opinions through open questions in the questionnaire. To sum up, it is found that there are three main reasons for the gap between online learning and face-to-face learning.

(1) *Online learning lacks the sense of teaching presence:* Although live broatcast platforms have broken the spatial and temporal limitations of learning, the learning environment is still different. For example, when watching live broadcast, students do not need to turn on the camera, so their behavior in class may become casual, and their attention is more easily distracted. In addtion, teachers can not observe the expressions and movements of students, so it is difficult to take care of everybody's learning status.

(2) *Lack of guidance for online group collaboration:* An example is an online group discussion, although an optional discussion topic is given and the discussion time is specified. However, due to the lack of scaffolding and the unfamilair relationship between group menmbers, it is inevitable that the discussion process is unclear, there is no decision maker leading the group discussion, and some slient students may be ignored during the group discussion.

(3) *Tedious process assessment of online learning:* In order to ensure the quality of online learning, assignments for lectures and discussions are provided on the CMS. For example, students need to take screenshots and take notes during the lecture, and upload screenshots, their comments to the CMS within the specified time. After the group discussion, students need to summarize their own views and ideas generated in the group discussion, and post and comment in the discussion board. Although these measures are conducive to teachers' process assessment of each student, they also increase the learning burden of students. Many students say that the overly compact activity arrangement leaves less time for them to reflect on the learning content deeply.

In summary, in view of the problems encountered in the summer school, the following suggestions are proposed.

(1) *For the lack of the sense of teaching presence:* Teachers are encouraged to adopt appropriate directional and guiding facial expressions and body language to attract learners' attention and mobilize the classroom atmosphere. Teachers can also use online interactive tools, such as live discussion boards and badges, to interact with students. In addition, the application of artificial intelligence technologies such as facial recognition and VR in the field of education will further enhance the sense of teaching presence.

(2) *For the lack of guidance for online group collaboration:* Instructional designers are supposed to formulate detailed process of group discussion, clarify the final results of group discussion, and equip teaching assistants for each group to guide the topic of group discussion in real time and answer students' questions in time.

(3) *For the tedious process assessment of online learning:* On the one hand, students can set their own pace of online learning, such as giving them enough time to reflect after class, and are allowed to repeatedly watch the recorded lecture videos and submit homework for many times. On the other hand, further innovation and application of artificial intelligence in education are needed to solve this problem, such as automatic attendance checking through face recognition technology.

VII. Conclusion

The continuation of the epidemic forced the instructional mode for the whole society to be changed from offline learning to blended learning or full online learning. The "high registration rate and low completion rate" of MOOC gave birth to the rise of SPOC. The full-online SPOC are first adopted in the "Frontier of Educational Technology" summer school of Peking university. With the help of applications such as the CMS, live-broadcasting platform, social media group, and activities such as ice-breaking trip, expert lectures, group discussion, group presentation, the effect of the summer school is positive. Both students' subjective evaluation of the learning experience and their course performance reflect students' high satisfaction with the summer school. In addition, the proposed suggestions for the 3 problems, such as lack of teaching presence, lack of guidance in group collaboration, and tedious process assessment, may bring some new inspirations to the SPOC practice and research being carried out widely in the world.

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