Do SPOC Really Improve Student Learning in Vocational Schools? A Meta-Analysis of Studies in Chinese Contexts

Jiang WUXUE
Department of Math & Information Technology, Education University Hong Kong, Hong Kong, China
s1131603@s.eduhk.hk, dsun@eduhk.hk

ABSTRACT
Published studies on SPOC provided inconsistent findings regarding its effectiveness. Adopting a meta-analysis method, this study combined the results of 32 experimental and quasi-experimental studies published in the past 8 years in China for analyzing the overall effect size of SPOC for improving student learning in vocational schools. Data analysis confirmed that SPOC has a moderate positive effect, with a combined effect size of 0.592 ($P<0.05$). Further analysis revealed three significant factors that moderate the effect of SPOC, including discipline area, group size, and knowledge type. SPOC has a larger effect size for disciplines of engineering technology and medical education than of natural science, and humanities and social science. Integrating SPOC for a small to medium-sized group with no more than 50 students brings about significant improvement in learning outcomes. Compared to declarative knowledge, SPOC is effective for developing procedural knowledge. The findings support the adoption of SPOC in vocational education. To amplify its impacts, multiple factors need to be carefully considered in the design and implementation.
KEYWORDS: Small private online course (SPOC), blended learning, meta-analysis, learning effectiveness, vocational education.

1. INTRODUCTION

1.1 Small-scale private online course (SPOC)

Small-scale private online course (SPOC) is a blended instructional model that applies massive online open course (MOOC) resources (e.g., videos, tests, discussion forums) to small-scale instructional scenarios (Fox, 2013; Fox, Patterson, & Walcott-justice, 2013). SPOC is small in scale as it involves a limited number of students in a single school or even a single class, and is private as its admission is restrictive and often requires registration and tuition fees (Freitas, & Paredes, 2018). SPOC harnesses the potentials of MOOC and accommodates its perceived problems such as difficulty in credit certification, high attrition rate, and superficial interaction (Kaplan, & Haenlein, 2016). SPOC translates established MOOCs into customized, niche-based online open courses to complement traditional instruction through blended learning approaches such as the flipped classrooms (Ramírez-Donoso, et al., 2021). It combines student-centered methods and resources with the conventional classroom-based instruction (Bansal, & Singh, 2015). The goal of SPOC research is to achieve organic integration of MOOC and classroom-based instruction to support and improve knowledge and skill development (Baggaley, 2014). Effective SPOC will provide a proved model for blended learning (Reininga, et al., 2015).

1.2 Related studies of SPOC

With the advent of the information age, innovative instructional models emerge, and traditional offline courses and online instruction are being integrated and blended. In SPOC, online interaction and on-site, offline instruction complement each other, conducive to in-depth learning and communication (Hadad, Shamir-Inbal, Blau, & Leykin, 2021). Many researchers of SPOC advocate its positive impact on educational practices. According to Loehr, et al. (2013), the integration of SPOC into software engineering courses significantly improved student learning efficiency. Jong (2016) also confirmed the positive role of SPOC for improved learning outcomes. Compared to MOOC, SPOC features teacher guidance, which was identified as the key contributing factor to such improvement. The privateness, another distinguishing feature of SPOC from MOOC, also facilitates learning. To access SPOC, formal registration is usually required; there is often a competitive application process and a tuition fee charged (Kaplan, & Haenlein, 2016); and the learning objectives and contents are personalized. These mechanisms all enhance student motivation for and participation in learning (Lockhart, et al., 2017).

From the perspective of teaching, SPOC is also impactful. Hadad, Shamir-Inbal, Blau, & Leykin (2021) acknowledged SPOC as an innovative approach to teacher professional development, curriculum construction, and discipline development. SPOC promoted the construction of international, online platform-based courses of good quality at a low cost. Leveraging these transnational tools and resources, teachers could keep in line with innovative, effective concepts and methods of instruction, construct, benchmark and improve curriculum, and further develop the discipline (Meriem, & Youssef, 2020). With SPOC, teachers could develop an international vision and enhance competitiveness, so could the curriculum, the discipline, and even the institution.

On the contrary, some researchers still hold a reserved view about the effectiveness of SPOC for augmenting learning. In Larson & Yamamoto (2013), there was no significant difference in learning outcomes between the SPOC experimental group and the control group who participated in traditional, lecture-based instruction in a computer technology course. SPOC will only be effective when the following is achieved: 1) tailored design based on learner attributes (e.g., age and cognitive style); 2) clear navigation and detailed annotation of learning resources; 3) real name registration and real-time monitoring; 4) visualization of learning process and progress; 5) responsiveness in discussion and interaction; and 6) proper evaluation and assessment (Müller, & Mildenberger, 2021; Björkdahl, Nyberg, Runeson, & Omérov, 2011). Meanwhile, credit certification and accumulation system of SPOC should be established and improved (Vallée, A., Blacher, J., Cariou, & Sorbets, 2020).

Overall, existing studies of SPOC provided inconsistent evidence about the effectiveness. And constraints such as a small sample size and low external validity that present in most published studies further impeded the reliability and generalizability of their conclusions. Meanwhile, the factors that influence the effect of SPOC need to be further investigated.

2. RESEARCH PURPOSE AND QUESTIONS

This study employed the meta-analysis method to systematically quantify the effect of SPOC for improving learning in vocational schools in China as reported in published experimental and quasi-experimental studies, and explore the factors that influence the effect of SPOC. The findings will inform future practices of SPOC for better outcomes of vocational education.

3. METHODOLOGY

3.1 Meta-analysis

Meta-analysis is widely used in educational technology research. Meta-analysis is a statistical analysis method that combines the results of multiple experimental or quasi-experimental studies to calculate the effect size of an intervention (Cooper, Hedges, & Valentine, 2019; Lipsey, & Wilson, 2000). The effect size (ES), i.e., the standardized mean difference (SMD) between the experimental group and the control group, could be calculated using formula (1).

$$ES = \frac{\overline{Y}^T - \overline{Y}^C}{S} \qquad (1)$$

In this formula, $\overline{Y}^T$ represents the mean value of the experimental group (SPOC group); Y^C represents the mean value of the control group (conventional instruction group); and S represents the standard deviation between the experimental group and the control group.

= (2)

For the total population, the effect size of SPOC could be calculated by formula (2). In this second formula,

is the mean value of population who experienced SPOC; is the mean value of the population without that

experience; and is the standard deviation between these two population.

To address the issue of heterogeneity among studies, i.e., the studies included differed in sample and intervention, two solutions have been developed. One is to use dummy variables to represent factors that introduce heterogeneity, and the other is to use a random effects model or fixed effects model in analysis. If sample heterogeneity is significant, the second solution should be applied. Based on the data for this meta-analysis, we used the random effects model. To eliminate the influence of heterogeneity, weighted least squares (WLS), where the reciprocal of standard deviation is used as the weight, was employed. In this study, Standardized Mean Difference (SMD) was used as the effect value to evaluate the impact of SPOC blended learning on students' learning performance，applying formula (3).

$$SMD = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{(n_1 + n_2 - 2)}}} \qquad (3)$$

In this formula, n_1 and n_2 represent the sample size of the experimental group and the control group respectively; $\bar{X}_1$ and $\bar{X}_2$ represent the mean value of the experimental group and the control group respectively, and s_1 and s_2 represent the standard deviation of the experiment group and control group respectively.

3.2 Literature search and selection

3.2.1 Literature retrieval

This meta-analysis focused on the effectiveness of SPOC for improving vocational education in China. The databases for identifying the target literature were the most influential academic platforms in China, including the China National Knowledge Infrastructure (CNKI), Wanfang database, and VIP database (Li, & Wang, 2022). The search keywords included SPOC, online course platform, blended teaching, blended learning, empirical research, applied practice, practical research, and applied research. To reflect recent, influential investigations on the topic, studies published before the year of 2014 and are not indexed in CSSCI journals or the core journals of Peking University were excluded. Duplicates were removed. At this literature retrieval stage, a total of 689 studies were collected.

3.2.2 Literature selection process and criteria

The 651 studies were exported for further screening and selection according to the following criteria: 1) the study should focus on the effectiveness of SPOC on student learning; 2) the study should be an empirical investigation; 3) the study should adopt an experimental or quasi-experimental method with a SPOC experimental group and a control group of conventional instruction and with a pre-test and post-test design; and 4) the study should provide all the necessary information and statistics including the sample size, mean, standard deviation, and effect value.
Four iterative cycles of screening were conducted, and resulted in a total of 32 studies for the final analysis, which met the criteria that the minimum number of studies required for a meta-analysis (Rienties, & Toetenel, 2016). All the studies were independent of each other. The selected studies adopted the Cohens'd, Hedges' G, or SMD to measure the effect size of the intervention, Thus, the total number of effect size of the studies retrieved was 32. In total, 1,825 students participated in SPOC as the experimental group, while 1,823 received conventional as the control group. The process of literature screening is shown in Figure 1.

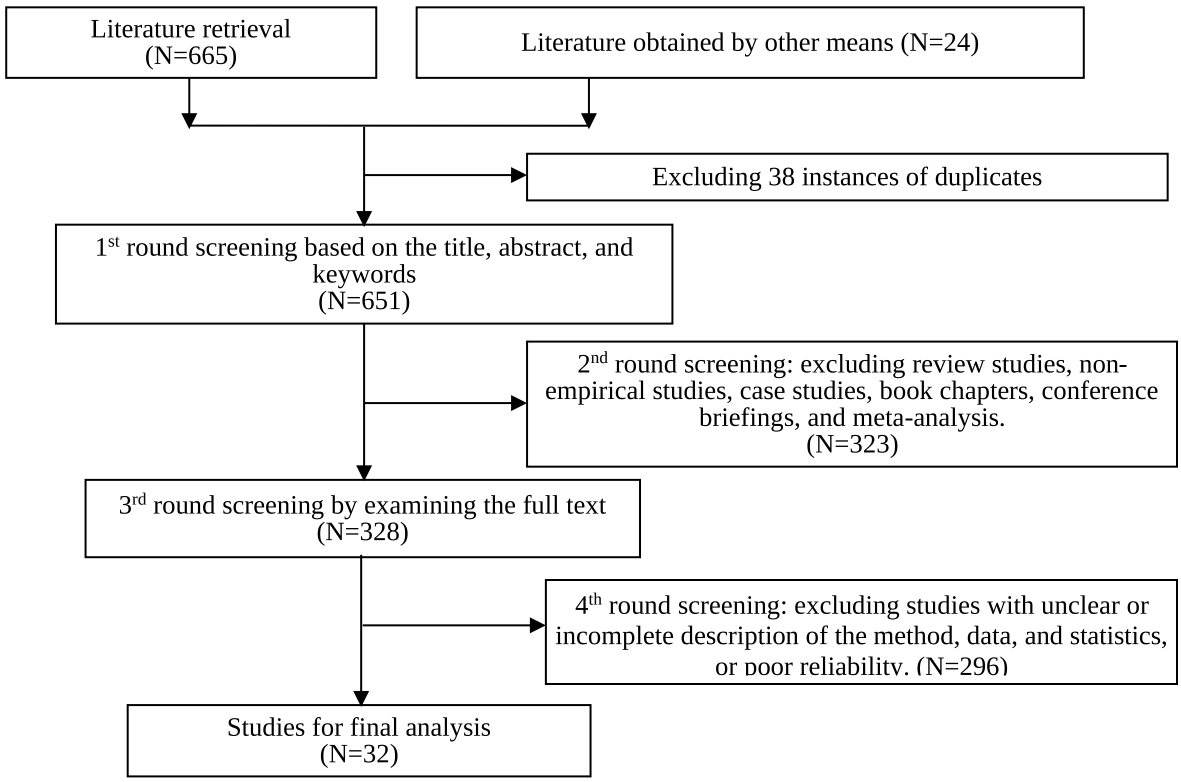

Figure 1: Literature screening process

3.3 Coding

In the following, the 32 studies were coded and categorized using the Microsoft 2019 Excel spreadsheet. Of each study, the author, year of publication, group size, length of intervention, discipline area, and knowledge type were annotated (Table 1). Learning effectiveness was proposed as the dependent variable, SPOC the independent variable, and group size, discipline area, knowledge type the moderating variables.

Table 1: Meta-analysis literature information for statistical purposes

No.	Author (Year)	No. of students		Discipline area	Group size	Length of intervention	Knowledge type
		E	C				
1	Yin, H. D. (2016)	39	30	2	2	2	1
2	Fu, X. H. (2017)	49	49	4	2	1	2
3	Feng, R. (2015)	50	49	4	2	3	1
4	Xia, Z. (2015)	46	42	2	2	2	2
5	Wang, X. L. (2017)	100	104	4	3	2	2
6	Zha, C. Y. (2019)	24	26	2	1	1	2
7	Chen,Y. (2021)	160	160	4	3	2	1
8	Zha, J. (2016)	90	86	2	3	3	2
9	Wang, L. (2021)	44	47	4	2	2	2
10	Wang, Y. (2019)	69	62	2	3	2	2
11	Chen, L. (2017)	51	51	4	3	2	1
12	Hu, S. Z. (2019)	29	30	4	1	1	1
13	Gao, W. (2017)	51	53	4	2	2	2
14	Tan, J. X. (2016)	50	54	2	2	2	2
15	Hu. H. (2022)	41	42	1	2	2	1
16	Ding, J. (2022)	24	26	3	1	2	1
17	Wu, Y. H. (2022)	35	35	2	2	2	2
18	Li, Y. (2022)	30	32	2	2	3	2
19	Xu, J. (2021)	34	34	2	2	2	2
20	Yang, Q. (2022)	40	40	2	2	2	2
21	Chen, L. (2020)	30	30	2	1	2	1
22	Shi, T. H. (2020)	30	30	2	1	2	2
23	Wang, W. X. (2018)	79	84	3	3	3	1
24	Yu, Y. (2020)	23	22	4	1	2	2
25	Shen, Y. (2019)	102	104	4	3	2	1
26	Shi, Y. L. (2018)	88	89	1	3	2	2
27	Ren, J. (2017)	96	96	3	3	3	1
28	Wang, J. J. (2018)	67	65	3	3	2	1
29	Chen, S. Y. (2017)	85	85	2	3	2	2
30	Xie, H. L. (2017)	113	111	2	3	2	2
31	Ming ShanTseng (2017)	30	30	3	1	2	1
32	Meng-Hsiun Tsai (2017)	26	15	3	1	2	1

Please refer to Table 1 for a summary of the coding scheme. The group size was categorized as 1) small, 2) medium, or 3) large. If the number of students in the experiment/control group was smaller than 30, the relevant study would be coded as having a small group size; if the number was between 30 and 50, the study would be coded as having a medium group size; if the number was larger than 50, the study would be coded as having a large group size. The discipline area involved in the studies was categorized as 1) natural science (including mathematics and statistics), 2) humanities and social science (including English, marketing, and human resources management), 3) engineering technology (including architectural technology and computer technology), or 4) medical education (clinical education and nursing education). The length of the intervention was categorized as 1) short (within 2 months), 2) medium (2-4 months); or 3) long (more than 4 months). Knowledge type was coded as 1)procedural knowledge, or 2) declarative knowledge. For a full list of the 32 studies and a summary of the coding results, please refer to Table 2.

Table 2: Coding dimensions and coding items

Dimension	Coding items
Group size	1. Small: 30 students per group 2. Medium: 30-50 students per group 3. Large: more than 50 students per group
Length of intervention	1. Short: within 2 months 2. Medium: 2-4 months 3. Long: more than 4 months
Discipline area	1. Natural science: mathematics and statistics 2. Humanities and social science: English, marketing, and human resources management 3. Engineering technology: architectural technology and computer technology 4. Medical education: clinical education and nursing education
Knowledge type	1. procedural knowledge 2. declarative knowledge

3.4 Data Analysis

Comprehensive Meta-Analysis (CMA3.0) was adopted to analyze data. CMA 3.0 is powerful for data integration and statistical analysis of effect size of multiple sets of data (Park, & Suh, 2021). In this study, the sample size, mean values, and standard deviation of each study collected was put into CMA3.0， All data were put into CMA 3.0 for analysis， Data processing in CMA has the following four steps. 1) The publication bias test is conducted to determine whether there is serious publication bias according to the publication bias funnel plot or Begg's rank (Pierce, 2008). If there is no publication bias, the second step is conducted. 2) According to value of I-square, make heterogeneity test and choose the random effects model or the fixed effects model. 3) The overall effect value determines whether SPOC blended learning has a significant effect on learning outcomes. 4) Conduct moderating variable analysis to determine whether there are significant differences among the moderating variables, that is, whether they have a positive impact on SPOC blended learning (Mavi, & Erbay, 2021).

4. RESULTS

4.1 Publication bias test

Publication bias occurs when the selected literature is not systematically representative of the overall body of research in the field (Torgerson, 2006). Publication bias may seriously compromise the validity of a meta-analysis. In this study, the funnel plot of effect value distribution and Begg's rank correlation test were used to measure whether our selection of published studies was biased or not. In the funnel plot derived (Figure 2), the 32 studies were evenly distributed on both sides of the spindle, indicating an absence of significant publication bias. The Begg's rank correlation test result further confirmed this observation. The publication bias value was not significant ($Z=1.297<1.96$, $P=0.195>0.05$). Integrating the funnel plot and Begg's test, we affirmed the representativeness of the selected studies of the research field investigated.

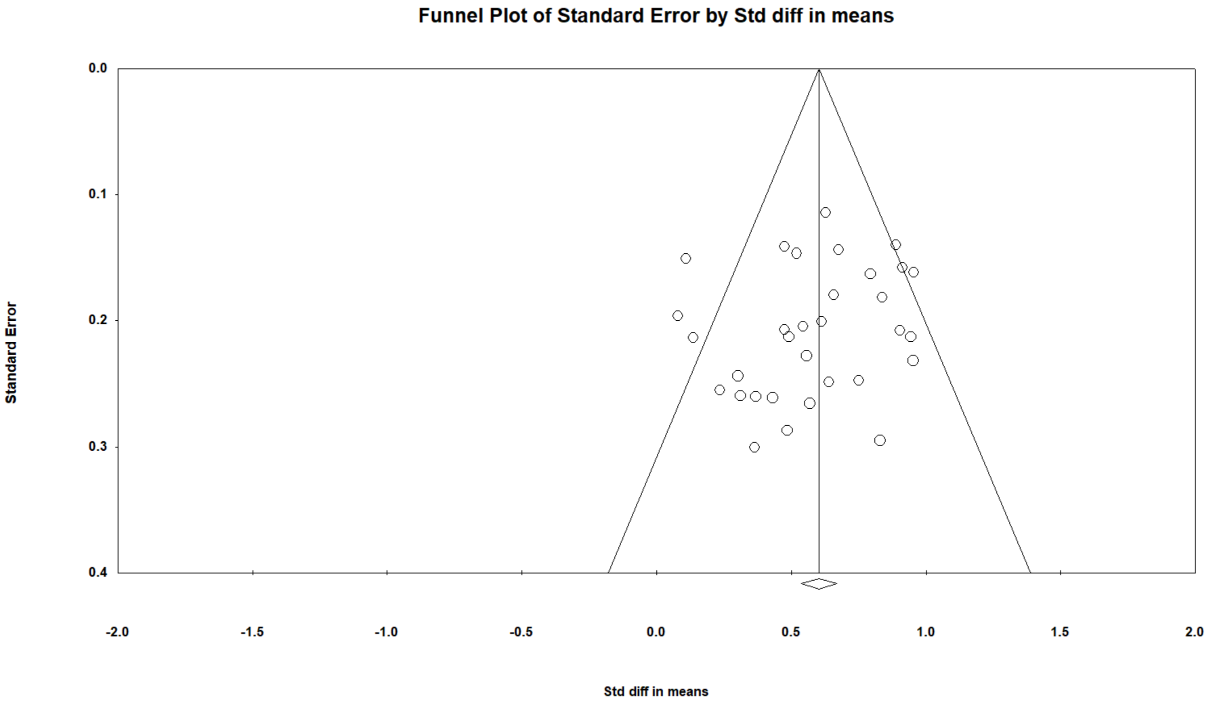

Figure 2: Funnel plot result

4.2 Heterogeneity test

Table 3 displays the results of the heterogeneity test. I-squared value represents heterogeneity. When the value is between 0 and 100, the greater the value, the greater the heterogeneity (Forsberg, Martinussen, & Flaten, 2017). In this study, the I-squared value was 82.153, indicating a high degree of heterogeneity among the studies selected. The heterogeneity reflected differences in sample and intervention. In meta-analysis research, the common practice is to use the fixed effects model for analysis if the heterogeneity value is small, and to use the random effects model when the heterogeneity value is large (Borenstein et al., 2021). Therefore, the random effects model was adopted in this study.

1: Heterogeneity test results and the random effects

Model	No. of Studies	ES (SMD)	S.E.	95% CI		Test of null (2-Tail)		Heterogeneity			
				Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared
Fixed	32.000	0.602	0.033	0.536	0.6681	17.836	0.000	123.613	31	0.004	82.153
Random effects	**32.000**	**0.592**	**0.047**	**0.500**	**0.684**	**12.647**	**0.000**				

4.3 The effectiveness of SPOC

The random effects shown in Table 3 revealed that the combined effect size (SMD) of SPOC for vocational education in the Chinese context was 0.592. The Z score was 12.647 (P<0.001), indicating a significant difference between the SPOC experimental group and the control group. According to Cohen (2013), an effect value less than 0.2 indicates poor effectiveness; an effect value indicates minor effectiveness; an effect value between 0.5 and 0.8 indicates moderate effectiveness; and an effect value equal to or greater than 0.8 indicates large effectiveness (Cohen, 2013). The result of this meta-analysis showed that SPOC has a moderate positive impact on student learning in vocational schools.

4.4 The influence of moderating factors

4.4.1 The influence of discipline area

In this meta-analysis, the discipline area that SPOC was applied to each study was categorized. How did SPOC impact the learning of different discipline areas was analyzed and the results are presented in Table 4. The effect size of SPOC for the learning of natural science, humanities and social science, engineering technology and medical education was 0.426 (P=0.012<0.05), 0.231(P=0.023<0.05), 0.801(P=0.005<0.05) and 0.712(P=0.009<0.05) respectively, indicating a positive effect of the intervention across discipline areas. The inter-group difference was also significant (Chi2=8.426, P=0.038 <0.05), suggesting discipline area being a moderate factor for the effectiveness of SPOC. When integrated into engineering technology and medical education, SPOC better facilitated student learning and brought about improved outcomes. This might be explained by the extra time for practice enabled by SPOC. With SPOC, much of the learning content was viewed online outside of the classroom, so the classroom-based instruction could be more focused on practice and application, which is crucial for a skill-based discipline.

Table 2: The effectiveness of SPOC for different discipline areas

Discipline area	No. of Studies	ES (SMD)	S.E.	95% CI		Test of null (2-Tail)		Inter-group effect size
				Lower limit	Upper limit	Z-value	P-value	
1. natural science	3	0.426	0.055	0.376	0.744	7.624	0.012	Chi^2=8.426 P=0.038
2. humanities and social science	14	0.231	0.044	0.295	0.453	5.189	0.023	
3. engineering technology	5	0.801	0.072	0.476	1.095	11.094	0.005	
4. medical education	10	0.712	0.091	0.384	0.935	7.811	0.009	

4.4.2 The influence of group size

The second factor that might regulate the effect of SPOC was the group size. Whether SPOC generated different impact on student groups of different sizes was examined and the results were provided in Table 5. The effect size of SPOC in a small, medium, and large student group was 0.932 (P=0.000<0.05), 0.715 (P=0.005<0.05), and 0.102 (P=0.125>0.05) respectively, indicating a significant positive effect of the intervention in small to medium sized student groups. The inter-group difference was also significant (Chi2=4.099, P=0.009<0.05), suggesting group size being a moderator for SPOC. Compared to small or medium groups, the effect value of SPOC intervention was not significant in large groups.

Table 3: The effectiveness of SPOC for differently-sized groups

Group size	No. of Studies	ES (SMD)	S.E.	95% CI		Test of null (2-Tail)		Inter-group effect size
				Lower limit	Upper limit	Z-value	P-value	
Small	8	0.932	0.221	0.536	1.335	4.213	0.000	Chi2=4.199 P=0.009
Medium	12	0.715	0.091	0.316	0.982	7.816	0.005	
Large	12	0.102	0.098	-0.276	0.354	1.041	0.125	

4.4.3 The influence of the length of intervention

We proposed the length of intervention being another moderating factor that influence the effectiveness of SPOC. Data analysis displayed in Table 6 rejected this proposal. The effect size of SPOC implemented for less than 2 months, 2-4 months, and more than 4 months was 0.624 (P=0.021<0.05), 0.689 (P=0.016<0.05), and 0.513 (P=0.028<0.05) respectively, indicating a significant effect of the intervention across time spans. The inter-group difference was not significant (Chi2 =1.096, P=0.578 > 0. 05). The integration of SPOC, in general, would improve student learning effectiveness regardless of its duration.

Table 4: The effectiveness of SPOC of different intervention length

Length of intervention	No. of Studies	ES (SMD)	S.E.	95% CI		Test of null (2-Tail)		Inter-group effect size
				Lower limit	Upper limit	Z-value	P-value	
Within 2 months	3	0.624	0.087	0.331	0.717	7.131	0.021	Chi^2=1.096 P=0.578
2 to 4 months	21	0.689	0.099	0.293	0.95	6.994	0.016	
more than 4 months	8	0.513	0.073	0.281	0.646	6.958	0.028	

4.4.4 The influence of knowledge type

This study also investigated whether the effect of SPOC was impacted by the type of the target knowledge in the intervention. As shown in Table 7, the effect size of SPOC for the learning of procedural knowledge was 0.630 (P=0.017<0.05), and for the learning of declarative knowledge was 0.348 (P=0.061>0.05). Compared to declarative knowledge, SPOC integration was effective in improving the development of procedural knowledge. This finding was consistent with the previous finding that SPOC was more effective in improving the learning of skill-based disciplines areas such as engineering technology and medical education which prioritized procedural knowledge. With regard to the inter-group effect, the difference was not significant (Chi2=0.815, P=0.367>0.05). These findings, in combination, suggested that the knowledge type be a moderating factor for the effectiveness of SPOC, but its moderating effect should be limited.

Table 5: The effectiveness of SPOC for different types of knowledge

Knowledge type	No. of Studies	ES (SMD)	S.E.	95% CI		Test of null (2-Tail)		Inter-group effect size
				Lower limit	Upper limit	Z-value	P-value	
Procedural knowledge	14	0.630	0.050	0.533	0.728	12.626	0.017	Chi^2=0.815 P=0.367
Declarative knowledge	18	0.348	0.048	0.400	0.697	7.229	0.061	

5. CONCLUSION AND DISCUSSIONS

In this meta-analysis, 32 experimental and quasi-experimental studies on SPOC in vocational education published in China in the past 8 years were analyzed and combined. The results showed that: 1) Compared to traditional classroom-based instruction, SPOC had a moderate positive impact on learning with an effect size of 0.592; 2) The discipline area that SPOC intervened was a factor that moderated its effectiveness. SPOC had a larger effect size for the learning of disciplines of engineering technology and medical education, and the combined effect size reached 0.801 and 0.712 respectively; 3) The group size was another moderating factor. In a small to medium-sized group or class, SPOC was more effective. 4) The time SPOC spanned had no significant influence on its effectiveness. As long as SPOC was integrated, the learning outcomes would be improved. 5) Knowledge type was a third moderating factor. When SPOC was engaged in the learning of procedural knowledge, the learning outcomes were significantly improved, with an effect size of 0.630. Yet for declarative knowledge, such improvement was not significant, with an effect size of 0.348.

5.1 SPOC has a moderate positive impact for improving student learning in vocational schools.

The meta-analysis reveals that the combined effect size of SPOC for vocational education was 0.592, indicating a moderate positive effect. SPOC integrates diverse instructional resources online and offline, and affords more time and space for classroom-based instruction. Compared to traditional, classroom-based instruction, SPOC is conducive to in-depth learning, and will bring about significantly better outcomes. Our finding is consistent with previous research. Take English education in vocational schools for example. Yang, & Feng (2022) introduced SPOC to the instruction of English writing. The dynamic and sustainable learning environment established in the study that leveraged online open courses not only improved students' English writing skills and language use, but also contributed to the reform of English education in vocational schools enabled by information and communication technologies by providing an operatable and effective model (Broadbent, 2017; Li, 2019).

5.2 Moderating factors for the effectiveness of SPOC: Discipline area, group size, and knowledge type.

We hypothesized four variables that would influence the effect size of SPOC. Analysis results confirmed the significant regulating effect of three factors, including discipline area, group size, and knowledge type. Despite the overall significant effect of SPOC across discipline areas, the intervention worked significantly better for instructing disciplines in the areas of engineering technology and medical education than of natural science and humanities and social science. Effective instruction of engineering-related disciplines, such as computer technology, mechanical engineering, and construction technology, usually prioritizes the experiences and development of critical skills such as design-thinking and problem-solving. The online-based resources of SPOC, especially videos and simulations, enabled students to observe and navigate these critical processes thoroughly (Masud, & Huang, 2012). Moreover, as some of the instructional contents and tasks are shifted to online, out-of-class time, the teacher and students will have more time to interact, discuss, evaluate, reflect, and feedback in classroom-based instruction sessions. These affordances of SPOC probably account for its particular benefits to the instruction of skill-based disciplines. Applying SPOC to disciplines of medical education that also highlight the cultivation of critical competencies of scientific inquiry and problem-solving, such affordances also produce improved results.

The second moderating factor for the effectiveness of SPOC is the size of the student group or class that SPOC is applied to. The smaller the group, the larger the effect size. When SPOC is applied to a class of no more than 50 students, student learning outcomes will be significantly better than those in a traditional classroom. On the contrary, for a large class of more than 50 students, the effect of SPOC is not evident. Implementing SPOC to a small-scale of students is advantageous. One the one hand, in a small class, the teachers will have more time to observe, scaffold, and reflect to each individual student. The facilitation and guidance are more abundant and specific. On the other hand, compared to a large class, teachers for small or medium-sized classes, will have limited workload in class management, homework correction and feedback, and evaluation and assessment, which leaves more time for them to develop and improve the instructional design and resources, and in turn contributes to better educational outcomes (Shen, & An, 2022).

The third factor that regulates the effectiveness of SPOC is knowledge type. For improving the teaching and learning of procedural knowledge, the integration of SPOC is significant, with a combined effect size of 0.630. For declarative knowledge, integrating SPOC can also improve student learning, with a combined effect size of 0.348, but the enhancement is not significant. Such discrepancy may be ascribed to the different characteristics and learning mechanisms of the two types of knowledge (Vo, Zhu, & Diep, 2017). Declarative knowledge is relatively abstract, and its development is mediated by processes of personal investigation, interactive discussion and negotiation, and further improvement through the collision of ideas (Lin, et al., 2017). Procedural knowledge is relatively structured, straightforward, and focused on the operation. The online platform may better complement the classroom-based instruction for the presentation, illustration, and further understanding of procedural knowledge.

With regard to the length of intervention, its moderating effect to SPOC is not significant. As long as SPOC is integrated, student learning in vocational education settings will be improved, regardless of its time of implementation. SPOC spanned more than 4 months will be slightly less effective than it is freshly introduced. This is probably because of the increasing familiarity with the blended model. Usually a novel, the innovative instructional model will enhance student motivation and enthusiasm, which provides the basis for effective learning (Li, & Wang, 2022). As time progresses, the effect of the novelty will decrease. But the overall impact of SPOC will not be compromised much.

6. IMPLICATIONS

This meta-analysis reveals that SPOC has a moderate positive effect for enhancing learning in vocational education, and supports wider application of this innovative blended learning approach. SPOC combines and leverages the strengths of both the online and offline learning spaces. Following this instructional model, the rich instructional resources and abundant opportunities for social interactions and self-directed learning embedded in the online platform are harnessed, and the learning mechanisms functioning in conventional classroom-based instruction are sustained (Richardson, Maeda, Lv, & Caskurlu, 2017). Adopting SPOC, student learning is more personalized, interactive, and facilitated, and therefore will be more effective (Saqr, Jovanovic, Viberg, & Gašević, 2022). Meanwhile, enrollment in vocational schools grows rapidly in recent years. For vocational educators, how to accommodate the increasing diversity of students in terms of knowledge structure, cognitive style, learning habits and alike becomes a big challenge (Castro, & Tumibay, 2021). Innovative instructional methods and models such as SPOC that provide abundant learning resources and support flexible time and space of learning should be further developed, evaluated and applied to meet the diversified needs of students. Vocational education institutions across levels and types should formulate plans for systemic implementation taking into account their specific context. And policy, technical and financial support should be devised and enacted to encourage, sustain and scale up these innovations.

6.1 Identify and harness the respective affordances of online and offline learning for designing and developing SPOC for different disciplines

According to this meta-analysis, SPOC has a moderate positive effect for improving learning across disciplines. It is also discovered that SPOC is more effective for the instruction of disciplines in the areas of engineering technology and medical education than in natural science, and humanities and social science, and more effective for learning procedural knowledge than declarative knowledge. The findings reflect both the value of SPOC and the areas for improvement in established practices. To further amplify the effect of SPOC across disciplines, more detailed analysis should be conducted to uncover the ingredients and mechanisms that contribute to the success or failure of a design and implementation. The online space and the classroom each possesses unique affordances to learning (Calderon, & Sood, 2020). Educational researchers and practitioners need to better understand the potentials and limitations of the two learning spaces, and organize and integrate them to maximize the positive effect. Meanwhile, the design and development of SPOC should also correspond to the characteristics and requirements of the discipline and the students. For example, students in vocational schools usually "work hard and love practice" (Nejkovic, & Tosic, 2018). Such learner knowledge should be accumulated and applied to SPOC design and development.

6.2 Plan for acculturation and control class size for better effectiveness

Despite the finding that the length of implementation of SPOC does not significantly affect its influence, similar to other educational innovations, a period of acculturation during which students gradually improve understanding of and proficiency in using the online platform, and develop the mindset and practices to integrate, bridge, and leverage the two different learning modes blended in SPOC should be planned. Moreover, as group size is a significant moderator for the effectiveness of SPOC. The class size of SPOC should be limited to no more than 50 students. Privateness is one defining feature of SPOC, and we should maintain this feature by limiting the class size for better effectiveness.

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