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The Efficacy of the MOOC+SPOC Synchronous Learning Model in Vocational Education for Process Control Systems

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Incorporating the Industrial Revolution into vocational education, particularly in enhancing curriculum and learning, encounters numerous obstacles. Utilizing technology in interactive learning is anticipated to actively involve learners and enhance their abilities in critical thinking, creativity, innovation, and problem-solving. This study emphasizes the limitations of traditional learning approaches in Process Control Systems and presents a novel framework of MOOC+SPOC Synchronous using a Research and Development (R&D) methodology. The Process Control System course encounters impediments that negatively impact the graduation rate, which is suboptimal. The merging of MOOC (Massive Open Online Course) and SPOC (Small Private Open Course) models into a synchronous MOOC+SPOC learning model seeks to enhance learning outcomes through the utilization of a cloud computing-based Virtual Remote Laboratory (VRLab). The outcome is a model that has been rigorously evaluated and proven effective through empirical

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research. The research data demonstrated this model's statistically significant positive effect on enhancing student learning outcomes. The Pre-Test and Post-Test results revealed that the experimental group experienced a notable improvement in learning outcomes, with an increase ranging from 10% to 46%. In comparison, the control group also exhibited increased learning outcomes, ranging from 5% to 39%. The statistical analysis reveals a consistent and significant growth in the Experimental group, indicating that students exhibit a favorable level of motivation throughout the learning process, as indicated by the average significance value exceeding 0.5. Based on the test findings acquired from this study, it can be concluded that the Synchronous MOOC+SPOC model is a viable alternative for addressing future difficulties in vocational education. This model is effective and has been proven to work.

Keywords: Vocational education; learning model; higher order thinking skills.

1. INTRODUCTION

The integration of automation technologies in the fast-expanding industrial sector necessitates substantial planning and support to ensure the availability of skilled human resources. Vocational education, being an institution that trains professionals for the workforce, consistently updates its curriculum. The construction of the curriculum is grounded in the principles of 21st-century learning, which maximizes the utilization of technology in the process of acquiring knowledge.

The primary objective of incorporating technology into the learning model is to facilitate learners in developing critical thinking, innovation, communication skills, teamwork, computer literacy, and collaboration [1]. Critical thinking skills are a component of Higher Order Thinking Skills (HOTS), which encompass problem-solving abilities [2]. Enhancing proficiency in HOTS (Higher Order Thinking Skills) and problem-solving abilities can be achieved by employing software simulation as a viable strategy. Competent and productive students possess valuable qualities that make them very competitive in the workforce [3]. Enhancing proficiency and efficiency can be achieved by employing technology that is visually appealing and tailored to the specific circumstances in the industrial sector [4].

2. METHOD

The type of research conducted is Research and Development (R&D), using a quantitative approach. Data was obtained using instruments given to respondents. The sample used is a purposive sample, where the respondents are students who program the Process Control System course at the engineering diploma program.

3. RESULTS AND DISCUSSION

3.1 MOOC + SPOC Learning Model

Online learning is a term used in the activity of gaining knowledge through a computer network-based learning environment. One of the learning models that use fully online learning is Massive Open Online Course (MOOC). This online learning model utilizes the web as its base, where all learning materials are available on a platform that can be accessed by anyone. The platform is designed to be user-friendly, making it easy for users to select courses, upload materials, and create exams [5]. However, in its implementation, the learning model experiences several weaknesses, including the decline in students' learning motivation, lack of interaction with teachers or other participants [6] and the difficulty level of learning content that is not suitable for students [7]. With these problems, it can be concluded that the MOOC learning model is less effective.

To further streamline learning, the MOOC model is combined with the Small Private Open Course (SPOC) learning model. The integration of these two learning models aims to provide a deep learning experience to students (Deep Learning), increase interaction between teachers and students, and create an effective discussion space in the classroom [8]. The MOOC+SPOC combined learning model can be used both to teach large-scale online classes and to guide learning in small classes [9]. The characteristic of MOOC+SPOC model is to integrate Before Class, During Class, and After Class activities [10].

3.2 Synchronous MOOC + SPOC Learning Model

This study presents a learning approach that combines MOOC (Massive Open Online Course) and SPOC (Small Private Online Course) using Virtual Remote Laboratory (VRLab) as the learning medium. The utilization of VRLab media is intended to elucidate the operations that take place in actual industrial settings when studying Process Control Systems. A VRLab, or a virtual laboratory connected via the internet, allows users to participate without any limitations of time or location, while achieving the same outcomes as traditional classroom learning [11]. Additionally, it offers real-time results and enhanced security [12]. The research employs a VRLab equipped with a LabVIEW interface, which is linked to the laboratory's process plant.

The MOOC + SPOC technique involves integrating online and in-person teaching methods by utilizing MOOC learning resources to tailor SPOC learning experiences specifically for vocational education purposes. This strategy enhances the learning experience by providing additional resources and customizing the SPOC learning content. It allows for the simultaneous teaching of online and face-to-face courses in sync with MOOC.

The synchronous MOOC+SPOC methodology is employed in the learning of Process Control System, utilizing the ATRIBUT platform to offer a blended teaching approach that combines online and offline instruction. This pedagogical approach amalgamates the benefits of conventional instruction with both online and offline instruction, culminating in exceptional integration. It enhances teachers' pedagogical abilities and fosters students' enthusiasm for learning, while also expanding their knowledge of industrial processes, so establishing a strong basis for university education and future career prospects.

The utilization of the Synchronous MOOC+SPOC approach in Process Control System education entails the participation of 2 instructors, 3 courses, and a total of 120 students. Teachers and students can enroll in the ATRIBUT platform to gain access to the learning materials on the Process Control System. This platform serves as an online communication tool for professors and students. It also allows students to complete assignments, conduct evaluations, encourage autonomous learning on mobile devices, and access VRLab for learning purposes. The teaching model is comprised of three distinct stages: Before Class, During Class, and After Class. The MOOC+SPOC Synchronous teaching paradigm is illustrated in Fig. 1.

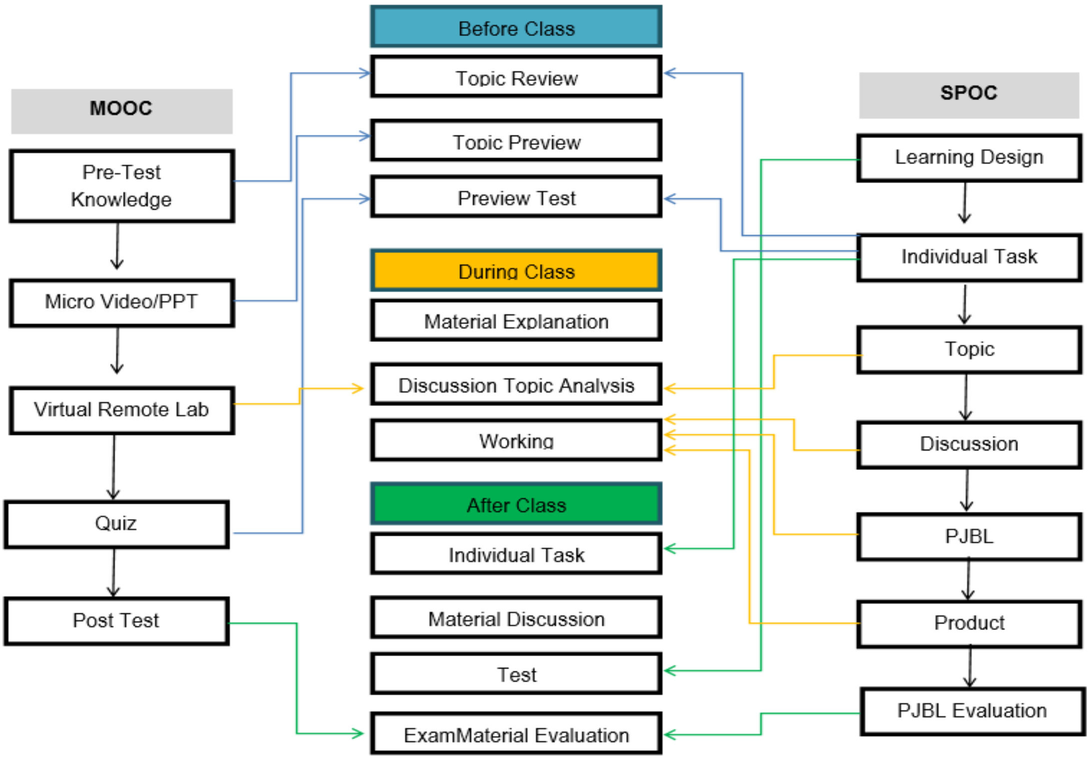

Fig. 1. Synchronous MOOC+SPOC model

3.3 Process Control Systems Course

Process Control Systems is a challenging subject offered in vocational education for engineering students. The course is known for its high level of difficulty and abstract nature, making it difficult to comprehend [13]. The course encompasses the examination of advanced mathematics, linear algebra, complex variable functions, automatic control principles, abstract concepts, mathematical reasoning, state variable feedback design, and ON-OFF and PID control [14]. Software simulation media are employed in project-based learning inside diploma programs to address authentic industry challenges. Utilizing learning media in these courses not only amplifies students' ingenuity in resolving issues, but also facilitates their acquisition of skills in resolving uncomplicated tasks [15].

3.4 Components of the Synchronous MOOC+SPOC Model

Synchronous MOOC+SPOC model has fulfilled 5 (Five) components contained in a learning model Weil (2003), namely:

3.4.1 Model syntax

The Synchronous MOOC+SPOC learning model developed has 3 (Three) stages, namely Before Class, During Class and After Class. These learning stages can be seen more clearly in Table 1.

Table 1. Synchronous MOOC+SPOC stages

Stages	Description	Media
Stages 1: Before Class	Teacher Activities: Prepare materials Monitoring student activities Prepare Pre Test and Post Test Student Activities : Listening to micro videos or studying PPT Take the quiz	 Platform ATRIBUT Platform ATRIBUT
Stages 2: During Class	Teacher Activities: Act as a facilitator in discussions with students. Conduct a review of previous learning. Conduct discussion or feedback on quiz questions. Conduct interactive discussion of the material. Directing the use of VR-Lab Conduct evaluation and reflection of learning at the end of the lesson Student activities: Taking the Pre-Test Conduct interactive discussion Using VR-Lab as directed by the instructor Doing project presentation Take the Post Test	Platform ATRIBUT Platform ATRIBUT Platform ATRIBUT Platform ATRIBUT
Stages 3: After Class	Teacher Activity: Conduct discussion Evaluate students' independent assignments Student Activities : Doing independent assignments Working on projects Conducting discussions Uploading assignments	Platform ATRIBUT Platform ATRIBUT Platform ATRIBUT

3.4.2 Social system

In the synchronous MOOC+SPOC learning model, social interaction takes place among students and between students and teachers, both online and offline.

3.4.3 Principles of reaction

In the Synchronous MOOC+SPOC paradigm, the instructor does learning reviews, facilitates classroom discussions, monitors discussions, assists learners in selecting project subjects, and conducts learning assessments.

3.4.4 Support system

The devices that support the learning process in the Synchronous MOOC+SPOC learning model include the Synchronous MOOC+SPOC model platform, Smartphone/Laptop, and internet connection.

3.4.5 Instructional Effect

The Synchronous MOOC+SPOC learning model has proven to be effective in teaching Process Control Systems. Students are able to grasp the fundamental concepts of industrial process control and develop the cognitive ability to create P&ID and mathematical models of industrial processes. Additionally, they acquire the psychomotor ability to operate Virtual Remote Laboratory equipment under the guidance of their teacher. Furthermore, students develop important affective abilities such as critical thinking, teamwork, communication skills, and problem-solving capabilities.

3.5 Effectiveness of MOOC+SPOC Synchronous Model

3.5.1 Improve the achievement of learning outcomes through active supervision during the learning process

The "ATRIBUT" platform, offering a comprehensive curriculum on Process Control System, enhances the effectiveness of the learning process. To exert control and supervise pupils' activities, a teacher can meticulously and intentionally organize learning materials. Students actively utilize the platform to study pre-learning modules and evaluate other learning materials.

The measurement data acquired from the ATRIBUT platform instrument yielded a significance value ranging from 0.419 to 0.682. This demonstrates the user-friendly nature of the ATRIBUT platform for both teachers and students in the context of learning Process Control Systems.

3.5.2 Strengthen the process assessment and realise HOTS and problem solving

Presently, the evaluation of courses continues to depend on closed examinations, which fail to accurately demonstrate the genuine proficiency of students. This system compels students to prioritize their attention on the final exam, often disregarding the gradual acquisition of knowledge in each class session. This leads to an unsustainable learning process, and the objective of cultivating innovative and practical skills is not attained. Hence, it is imperative to enhance the evaluation of every procedure, wherein students engage in a more proactive manner, while the teacher assumes a more facilitative role. This is intended to enhance the caliber of instruction.

The learning process in this MOOC+SPOC Synchronous incorporates a Project Based Learning (PjBL) approach. Students gain fundamental knowledge, engage in discussions, develop elementary projects, and present the outcomes of their efforts. The presentation receives comments from other attendees and influential educators.

The learning approach elicited highly favorable comments and had a significant impact on students. The measured results of the instrument can be observed in Table 2.

3.5.3 Improving student learning outcomes in the process control system course

To further illustrate the effectiveness of this developed model, the average score and the level of excellence of the MOOC + SPOC Synchronous model compared to the traditional model in learning Process Control Systems are measured. The effectiveness of learning is measured from the Pre-Test and Post-Test results in the Experimental Group and Control Group. A total of 40 respondents in each group were involved in testing the effectiveness of the MOOC + SPOC Synchronous model in learning Process Control Systems.

From the measurement results using the student ability test instrument, the results are shown in Table 3.

Table 2. Student response measurement results

No.	Instrument Items	Significance Value
1	The learning process makes me always try to be there on time.	0,652
2	The learning process increases my enthusiasm in learning.	0,777
3	The learning process allows me to actively participate in lectures.	0,798
4	The learning process sharpens my critical attitude in identifying problems.	0,742
5	The learning method improves my understanding of the learning material.	0,746
6	Learning methods make me able to identify problems.	0,778
7	Learning methods enable me to solve problems.	0,839
8	Learning methods make me able to make physical models of industrial processes.	0,78
9	Course materials are relevant to current technological developments.	0,503
10	Learning methods make me skilled in using Virtual Remote Laboratory (VRLab) technology.	0,501
11	The learning method makes me skilled in using LabVIEW software.	0,546
12	The learning method makes me skilled in writing project reports.	0,687
13	The learning method makes me have social skills in discussion.	0,799
14	The learning process trains my co-operation with fellow students.	0,707
15	The learning process helped me in completing independent and group assignments.	0,738
16	The learning process makes me dare to argue and respect the opinions of fellow students	0,828
17	The learning process is conducive and fun.	0,720

Table 3. Measurement results of the ability test instrument

	EXPERIMENT		CONTROL	
	Pre-Test	Post- Test	Pre-Test	Post- Test
N	40	40	40	40
Min	10	80	9	30
Max	30	100	23	100
Mean	20,20	94,50	11,20	80,13

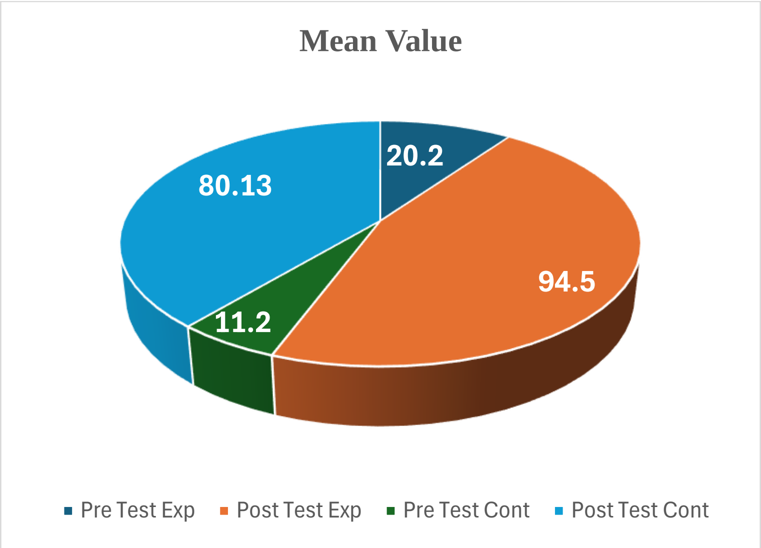

Fig. 2. Mean pre-test and post-test values

The data showed that the Control Group had the lowest score of 9 on the Pre-Test and the highest score of 23. On the other hand, the Experimental Group had the lowest score of 30 on the Post-Test and the highest score of 100. Although both groups experienced improvement, for the Experimental Group, all students achieved a score above 50 after the learning. In contrast, in the Control Group, the improvement in learning outcomes was uneven across the sample, with some students still scoring below 50. This indicates an excellent increase in learning outcomes on the use of the Synchronous MOOC+SPOC teaching model, as can be seen in the mean scores of the Pre Test and Post Test results in Fig. 2.

The experimental group observed a percentage increase in learning outcomes from 10% to 46%, whereas the control group witnessed an increase from 5% to 39%. It can be inferred that there is a rise in learning outcomes when comparing the experimental group to the control group, as depicted in Fig. 3.

When examining the H0 research hypothesis, which asserts that there is no impact of the learning model on student learning outcomes before and after implementing the Synchronous MOOC + SPOC model, the significance level (Sig.) was evaluated. The probability value of the Shapiro-Wilk test is 0.175 for the Experiment Pre Test and 0.042 for the Experiment Post Test. due to the abbreviation "Sig." If the probability value of the Shapiro-Wilk test exceeds 0.05, it can be inferred that the data is not normally distributed. In addition, the results of non-parametric testing using the Wilcoxon Test were derived from the data presented in Table 4.

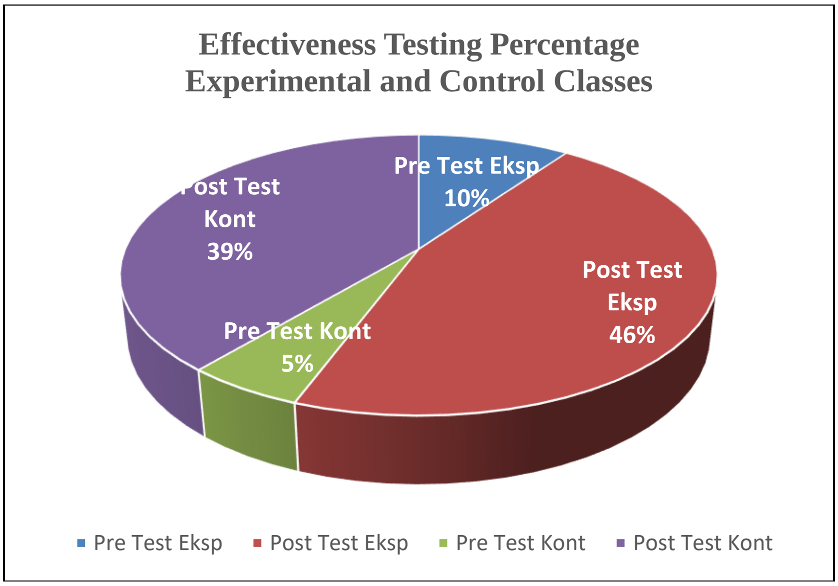

Fig. 3. Effectiveness percentages of experimental group and control group

Table 4. Wilcoxon test results

		N	Mean Rank	Sum of Ranks
PostExp - PreExp	Negative Ranks	0[a]	0,00	0,00
	Positive Ranks	40[b]	20,50	820,00
	Ties	0[c]		
	Total	40		
PostCon - PreCon	Negative Ranks	0[d]	0,00	0,00
	Positive Ranks	40[e]	20,50	820,00
	Ties	0[f]		
	Total	40		

a. PostExp < PreExp, b. PostExp > PreExp, c. PostExp = PreExp, d. PostCon < PreCon, e. PostCon > PreCon, f. PostCon = PreCon

Table 5. Significance values of wilcoxon test

Test Statistics[a]		
	PostExp - PreExp	**PostCon - PreCon**
Z	-5.515[b]	-5.514[b]
Asymp. Sig. (2-tailed)	0,000	0,000
a. Wilcoxon Signed Ranks Test b. Based on negative ranks.		

From the table it can be seen that there is no decrease in the value of the test results (Negative Rank = 0), but an increase in test results (positive ranks). And there are no equal scores between Pre Test and Post Test. Furthermore, the significance value of the Wilcoxon test results can be seen in Table 5.

The Significance value of the Wilcoxon test obtained 0.000 is smaller than 0.05 so that the H0 hypothesis is rejected that there is no effect of the learning model on student learning outcomes before and after using the MOOC+SPOC Synchronous model.

4. CONCLUSION

This article reviews a combined online and offline teaching method based on MOOC+SPOC Synchronous. Through the MOOC platform, the SPOC structure of the Process Control System course is developed using the "ATRIBUT" platform and implemented in vocational diploma education. The data showed positive significance, proving the effect of this model on improving student learning outcomes through Pre-Test and Post-Test in the Control group and the Experimental group showed an increase in experimental group learning outcomes from 10% to 46% while the control group increased from 5% to 39%. The statistical results showed a steady increase in the experimental group; this showed that students had positive motivation during the learning process, evidenced by an average significance value above 0.5. From the test results obtained from this study, the MOOC + SPOC Synchronous model can be considered a solution to overcome future challenges in vocational education, where the model offers an effective and tested approach. Ultimately, the effectiveness of this teaching technique is described by the measurement of student reaction, evaluation, and achievement of course objectives.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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