

The Effect of Seamless Learning on Understanding Concepts and Critical Thinking Abilities

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The purpose of this study is to investigate the effects of Seamless Learning on the understanding of concepts and the ability to think critically. It compares Seamless Learning (SL) with conventional strategies using a quasi-experimental research design with a 2x2 factorial. The study involved a sample of 76 students who had enrolled in Islamic education courses in the first semester in the academic year of 2019/2020 of the State University of Malang, Indonesia. The samples were divided into two groups, experimental and control. The experimental group consisted of 39 students who used the SL strategy, while the control group comprised 37 students using a conventional strategy. The study used a test instrument in the form of multiple-choice and essay, measuring the understanding of concepts and critical thinking abilities, respectively. Data then were analysed using Multivariate Analysis of Variance (MANOVA), assisted by SPSS 23 for Windows. The results showed a significant difference between the experimental and control groups towards understanding concepts and critical thinking. The experimental groups had a better understanding of concepts and critical thinking than the control class. These results indicate that the learning process with the SL strategy proves that it can improve students' understanding of concepts and critical thinking.

Key words: *Seamless learning, Understanding of concepts, Critical thinking abilities, Project based learning.*

Introduction

Critical thinking is the process of constructing knowledge through reflection and deep thinking (Saleh, 2019). Critical thinking is the ability to identify, analyse and evaluate ideas and information to formulate responses to a problem (Wongsila & Yuenyong, 2019). Critical

thinking, refers to 1) awareness of a series of critical questions that are related; 2) the ability to ask and answer critical questions in an appropriate way; and 3) actively have the will to use critical questions (Browne, M. Neil & Keeley, 2015).

According to Krathworl (2002), indicators for measuring critical thinking skills include: analysing (C4), evaluating (C5), creating (C6) (Anderson, Lorin W. & Krathwohl, 2001). To develop critical thinking skills, what one must do is increase understanding (Limbach & Waugh, 2010). Thus the understanding of concepts affects the ability to think critically. Therefore, it is necessary to find solutions to improve the understanding of concepts and the ability to think critically. One learning model that can improve conceptual understanding and critical thinking is seamless learning (Song & Wen, 2018; Lung-hsiang Wong, 2012). Its designs emphasise diversity in context and use personalised learning, and therefore, it can train students' thinking skills and problem-solving abilities.

The word seamless implies integration of separate parts to make them intact (Lung-hsiang Wong, 2015). Seamless learning is carried out continuously in formal, informal, individual and social contexts, physical, and digital platforms. It refers to the seamless integration of learning experiences in various dimensions and contexts and aims to improve the scope of learning by enlarging learning space from home to school (Song, 2018; L. H. Wong & Looi, 2016). Generally, it requires linking different learning environments, including formal, informal, individual, social, physical and digital learning spaces (Milrad, Marcelo; Wong, Lung-Hsiang; Sharples, Mike; Hwang, Gwo-Jen; Looi, Chee-Kit and Ogata, 2013).

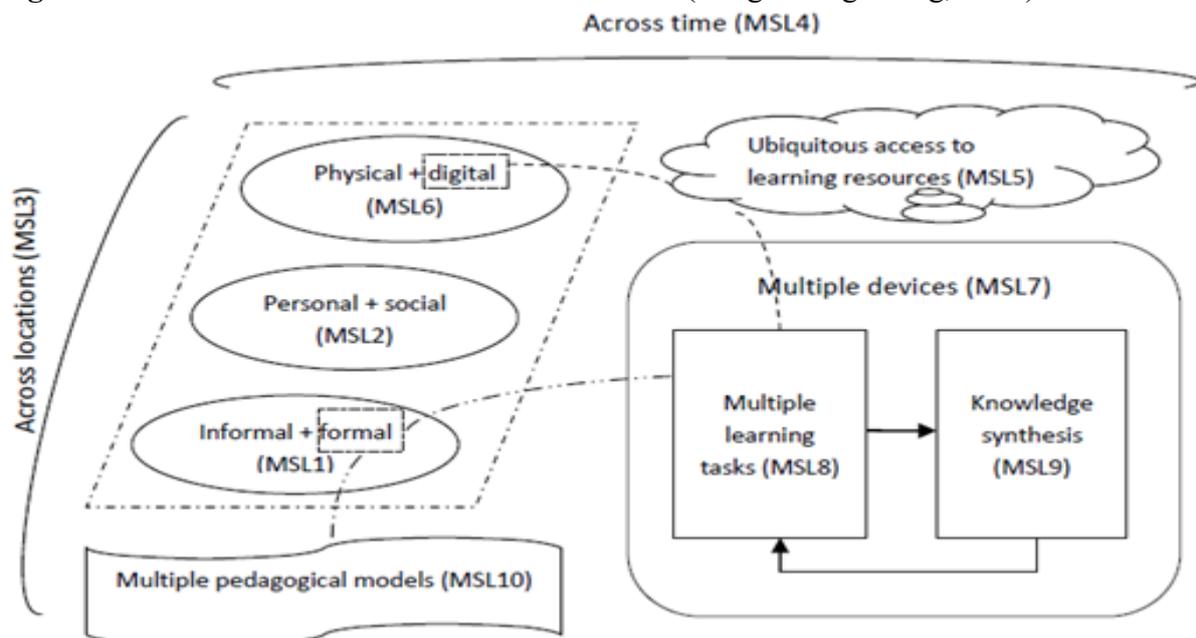
Seamless learning refers to the integrated and synergistic effects of learning in formal and informal settings, which are distributed across a variety of learning processes and spaces (Toh et al., 2013). It is characterised by two main things, adaptive and seamless connectivity (Otero et al., 2011). In adaptive seamless, students use technological devices, while in seamless connectivity, the learning process takes place anywhere and anytime, both formally and informally.

Formal learning involves teaching programs which are generally recognised by qualifications or certificates. In contrast, informal learning results from daily activities related to work, family or recreation (Cameron & Harrison, 2014). The implementation of these two learning models is carried out separately, though they support each other to achieve the set objectives. Several institutions have tried to combine the two models unsuccessfully (Kukulka-hulme et al., 2011). The use of formal learning cannot solely equip students with all the knowledge and skills needed (Amaluddin et al., 2019; Lung-hsiang Wong, 2012). The learning experiences occur not only in the classroom but also outside, and therefore, linking the two is vital for creating smooth learning and academic success (L. H. Wong & Looi, 2011; Lung-hsiang Wong, 2012). In general, integrating formal, informal and project learning is the main

focus of seamless learning (Lung-hsiang Wong, 2012). Learning supported by learning projects can accommodate experiences outside the classroom. Thus the research will integrate seamless learning with project learning.

Seamless learning consists of ten dimensions, including (MSL1) Formal and informal learning; (MSL2) personal and social learning; (MSL3) across time; (MSL4) cross-location; (MSL5) access to various learning resources; (MSL6) covers the physical and digital worlds; (MSL7) combining various types of devices; (MSL8) involves the movement between several learning tasks (such as data collection, analysis, and communication); (MSL9) knowledge synthesis, which is a combination of previous and new knowledge, several levels of thinking skills, and multi-disciplinary learning; (MSL10), which includes several learning models (L. H. Wong & Looi, 2016).

Figure 1. Visualisation of the 10D-MSL dimensions (Lung-hsiang Wong, 2012)



It aims to ensure students learn whenever they want, switching between different contexts, such as formal, informal, individual and social learning. Additionally, it helps to expand social spaces where students interact with each other (Lung-hsiang Wong & Looi, 2019). Encouraging students to integrate various learning experiences in their competencies is one of the central pedagogical goals of unlimited learning (Dilger et al., 2019).

This study aims to determine the effects of Seamless Learning on understanding concepts and students' critical thinking skills. This research follows up and completes the results of previous studies, specifically the effect of seamless learning on understanding concepts and critical thinking skills. To achieve these objectives, the research is conducted by testing two

groups, using seamless learning and conventional learning strategies. Therefore, this study can answer the following two problems.

1. Is there any difference in the understanding of concepts between students taught by SL and conventional strategies?
2. Is there any difference in the ability to think critically between students taught using SL and conventional strategies?

Method

This study used a quasi-experimental design with 2X2 factorial. It involved two groups, including an experimental class that used SL and the control class using conventional strategy. The experimental group used the Learning Management System (LMS). The design of this study can be seen in the following table:

Table 1: Research Design

Group	Pre-test	Treatment	Post-test
1	O ₁	Seamless Learning	O ₂
2	O ₁	Conventional	O ₂

This study involved students enrolled in Islamic education courses in the first semester in the academic year of 2019/2020 at Malang State University. A total of 39 and 37 students were placed in experimental (SL) and control groups (conventional), respectively. The topic used to test the effect of SL was "Integration of religious values in local culture in Indonesia." The choice of topics considers the suitability of competencies students need with a SL strategy.

This research consisted of two stages, including preparation and experimental phases. The preparation phase included a preliminary study activity on Islamic education, syllabus preparation, testing the validity and reliability of the instrument. The second phase as experimental, which consisted of two activities; pre-experiment and experiment. Pre-experiment is carried out by giving a pre-test, precisely concept understanding and critical thinking test. Experimental activities were carried out for six weeks, including the post test.

Seamless Learning and conventional learning steps can be seen in the following Table 2.

Table 2: Steps SL and conventional strategy

Context	Step	Seamless Learning	Context	Conventional strategy
Informal	Access and learning materials via online/offline	<ul style="list-style-type: none"> - Study material both online and offline - Watching videos - Online discussions - Task summaries - Answer to the test questions 		<ul style="list-style-type: none"> - Orientation
Formal	Class discussion	<ul style="list-style-type: none"> - Group discussion - Identify the problem 		<ul style="list-style-type: none"> - Group discussion - Identify the problem
	Design the Task theme	<ul style="list-style-type: none"> - Determine the theme of the task - Making tasks work steps 		<ul style="list-style-type: none"> - Determine the theme of the task - Making tasks work steps
	Making tasks work steps	<ul style="list-style-type: none"> - Uploading the results of the discussion - Presentation 		<ul style="list-style-type: none"> - Presentation
Informal	Doing task	<ul style="list-style-type: none"> - Conducting observations and interviews with the community - Analyse the findings - Hold online discussions - Make a report - Uploading report 		<ul style="list-style-type: none"> - Looking for information about problems in society via online - Analyse the findings - make a report
Formal	Report presentation	<ul style="list-style-type: none"> - Presenting report - Question and answer - Revised report - Uploading a revised report 	Formal	<ul style="list-style-type: none"> - Presenting report - Question and answer - Revised report

The data was collected through concept understanding and critical thinking tests. The test questions related to Bloom's cognitive thinking level revised by Anderson & Krathwohl (Anderson, Lorin W. & Krathwohl, 2001). The questions ranged from C1 to C3, including remembering (C1), understanding (C2), applying (C3). Importantly, the test questions to measure critical thinking skills related to four indicators, including the following; 1) a simple explanation (elementary classification), 2) build basic skills (basic support), conclude (inference), 3) make further clarity (advanced) and 4) arrange models and tactics (models and tactics) (Fisher, 2011). The critical thinking test questions involved an essay consisting of five questions, while the assessment rubric for analysing essential questions of thinking

was developed by Zubaidah and modified by Finken and Ennis (Zubaidah, Siti. Aloysius, 2018). The test was validated by three experts and was declared fit to be used as a measurement tool.

The data was collected from the concept of understanding test and critical thinking ability. They were analysed by inferential statistical analysis techniques using Multivariate Analysis of variance (MANOVA). Further, this analysis is used to reveal differences in concept understanding and critical thinking skills between the experimental and control groups.

Results

Description Data of Post Test Learning Outcomes

Analysis of the ability to understand concepts and think critically between SL strategy and conventional strategy is shown in Table 3.

Table 3: Descriptive Statistics

	Group	Mean	Std. Deviation	N
Concept Understanding	Control Group	70.9459	8.56656	37
	Experimental Group	78.4615	8.59573	39
	Total	74.8026	9.32526	76
Critical Thinking	Control Group	68.2432	9.94542	37
	Experimental Group	77.5641	10.18718	39
	Total	73.0263	11.04774	76

Table 3 shows that the results of understanding the concepts of the experimental group students ($X = 78.46$, $Sd = 8.59$) were more successful than the control group ($X = 70.94$, $Sd = 8.56$). Additionally, significant differences were found between the two groups in the critical thinking ability of the experimental group ($X = 77.56$, $Sd = 10.18$) which had higher results than the control group ($X = 68.24$, $Sd = 9.94$).

Testing Data Normality

A normality test is used to determine the data that has been collected in normal distribution.

Table 4: Normality Test of Understanding Concept

Tests of Normality							
	Learning Strategy	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Understanding concept	SL	.121	39	.155	.971	39	.398
	Conventional	.114	37	.200*	.972	37	.460

a. Lilliefors Significance Correction

The Kolmogorov-Smirnov and Shapiro-Wilk Lilliefors Correction Significance test results are as follows: (1) through the Kolmogorov Smirnov Test, the researchers obtained the significance level of the conceptual understanding test results above 0.05 (0.155 and 0.200), so it can be concluded that the conceptual understanding data are normally distributed. 2) through Shapiro-Wilk, the researchers obtained the significance level of conceptual understanding tests above 0.05 (0.398 and 0.468), so it can be concluded that the distribution of conceptual understanding data is normally distributed.

Table 5: Normality Test of Critical Thinking

Tests of Normality							
	Learning Strategy	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Critical Thinking	SL	.130	39	.094	.947	39	.068
	Conventional	.121	37	.192	.965	37	.291

a. Lilliefors Significance Correction

Through the Kolmogorov Smirnov test, with a significant level of critical thinking test results obtained above 0.05 (0.094 and 0.192), it can be concluded that critical thinking data presented with a normal distribution, through Shapiro-Wilk, the researchers obtained the significance level of critical thinking test results above 0.05 (0.068 and 0.291), it can therefore be concluded that critical thinking data is normally distributed.

Homogeneity Variant

The homogeneity of variance in this study was tested using the Levene's test. The Levene's test uses a significance level of 0.05, which means that if the significant value (sig) is greater than 0.05, the research data are homogeneous while if the significant value (sig) is less than 0.05, the research data are not homogeneous.

Table 6: Test of Homogeneity of Variances

Levene's Test of Equality of Error Variances^a				
	F	df1	df2	Sig.
Concept Understanding	.001	1	74	.976
Critical Thinking	.090	1	74	.765

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Group

Based on the Levene's Test, the result obtained revealed a significance level or probability of an average understanding of the concept above 0.05 which is 0.976. Likewise, the significance level of critical thinking ability is 0.765, this is also above the value of 0.05. It can be concluded that the variance of the sample is homogeneous. Based on the test results of these two assumptions, namely the normality test and the homogeneity test, it can be concluded that to test the analysis of variance with MANOVA can be done.

Test Results of the Influence of Learning Models on the Understanding of Concepts and Critical Thinking Skills

Analysis of the influence of learning models on the understanding of concepts and critical thinking skills is shown in Table 7.

Table 7: Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Concept Understanding	1072.455 ^a	1	1072.455	14.563	.000
	Critical Thinking	1649.547 ^b	1	1649.547	16.266	.000
Intercept	Concept Understanding	423835.613	1	423835.613	5755.271	.000
	Critical Thinking	403656.126	1	403656.126	3980.405	.000
Group	Concept Understanding	1072.455	1	1072.455	14.563	.000
	Critical Thinking	1649.547	1	1649.547	16.266	.000
Error	Concept Understanding	5449.584	74	73.643		
	Critical Thinking	7504.401	74	101.411		
Total	Concept Understanding	431775.000	76			
	Critical Thinking	414450.000	76			
Corrected Total	Concept Understanding	6522.039	75			
	Critical Thinking	9153.947	75			

a. R Squared = .164 (Adjusted R Squared = .153)

b. R Squared = .180 (Adjusted R Squared = .169)

Table 7 shows the understanding of the concepts of the experimental and control groups $F = 14,563$ and significance $0,000 < 0.05$. This means that there is a significant difference between the concepts of SL and conventional strategy. Table 7 also shows the critical thinking of seamless learning groups and conventional models $F = 16,266$ and significance $0,000 < 0.05$. This shows that there is a significant difference in the ability to think critically between SL and conventional strategy.

Discussion

The research findings show a significant difference in conceptual understanding between SL and conventional strategy. Students in the SL class have a higher concept of understanding compared to their counterparts in the conventional classes. This is consistent with the opinions of some learning experts who use the Seamless learning strategy to develop intellectual abilities (Mafunda & Swart, 2020). In general, the Seamless learning strategy makes students practice independently to solve problems through online and offline, formal and informal, and social and individual bases.

The Seamless learning strategy uses technological devices (cellular) to support students (L. H. Wong & Looi, 2011). Advances in cellular technology enable various applications to be developed and used in the learning process (Hernawati et al., 2020). Cellular technology has the potential to improve learning outcomes significantly. This potential is realised in case students have developed the habit of thinking about the effective use and utilisation of cultural and social resources in order to connect between formal and informal knowledge (Toh et al., 2017). The cellular technology has several advantages, including access to multimedia, communication, representation, information sharing, construction knowledge, connectivity, reference, and analysis (Song, 2011). Inquiry-based learning in digital and physical environments supported by mobile technology improves cognitive learning achievement (Shih et al., 2011).

Previous studies established that technological devices enable students to learn continuously in various contexts (L. H. Wong & Looi, 2011). Research on seamless learning using "Bring Your Own Device (BYOD)" showed that students who use mobile devices to learn fluently have better learning achievements (Song, 2014). Research on seamless learning using "Bring Your Own Device (BYOD)" showed that students who use mobile devices to learn fluently have better learning achievements (Lung-hsiang Wong, 2012). The results indicated that the post-test scores increased significantly from the pre-test.

The implementation of SL emphasises the student-centred learning process, which encourages students to be more active. They can find their own answers to solve the problem either through experiments or recording information. By studying independently, they gain their own knowledge through hands-on experience. SL is more superior to conventional models when it comes to improving critical thinking skills. The seamless learning strategy emphasises continuity in learning experiences and contextual learning (Lung-hsiang Wong & Looi, 2019). It has an effect on the acquisition of students' knowledge, achievements, attitudes, and motivations (Creswell John W., 2018). The seamless learning approach is effective in improving field observation performance (Hung et al., 2013). It ensures a continuous learning experience in various scenarios or contexts, and therefore, improves critical thinking skills (L Wong et al., 2012). Seamless learning has been widely adopted in pedagogical design to support student's scientific inquiry ability and develop critical thinking skills. Besides, the seamless learning approach can also increase motivation and activeness of students (Nordmark, S. Milrad, 2015).

Conclusion

This study concludes that SL can improve the understanding of concepts and critical thinking skills. It proves that SL is an innovative model which can be effective in improving the understanding of concepts and the ability to think critically. Nevertheless, it involves formal



and informal settings, which have limitations in monitoring learning activities. In future studies, the following recommendations are needed: 1) To encourage personalisation of student learning and examine individual activities in the informal learning activities. 2) To use an application that directly detects student activity in the online learning process.

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