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Measuring the Improvement of Students' Critical Thinking Abilities through Seamless Learning: A Quasi-Experimental Approach

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ABSTRACT

Background. 21st century education emphasizes the importance of developing high-level thinking skills (HOTS) for students, including analysis, evaluation and synthesis skills. Seamless learning, which integrates technology and media, becomes relevant in this context because it creates a dynamic and connected learning experience.

Purpose. This research aims to measure the increase in students' critical thinking abilities through seamless learning using quasi-experimental methods. By adopting this approach, the research seeks to provide empirical evidence about the effectiveness of seamless learning in improving students' critical thinking abilities.

Method. This research methodology takes a quantitative approach with quasi-experimental methods. Data was collected from a school in West Sumatra, with research subjects being grade 7 students. Data collection was carried out through critical thinking ability test instruments before and after the learning period. Analysis was carried out using the t-test in SPSS to compare the two groups.

Results. The results of the analysis showed significant differences between the experimental and control groups, with a greater increase in critical thinking ability scores in the experimental group. The resulting t value was 0.05, with a p value of less than 0.05, indicating that the difference between the two groups did not occur by chance. This confirms that seamless learning has a positive impact in improving students' critical thinking abilities.

Conclusion. These findings highlight the success of seamless learning in improving students' critical thinking abilities. However, this study has limitations, such as the relatively small sample size and limited duration of the intervention. Further research with larger sample sizes is recommended to deepen this understanding.

KEYWORDS

HOTS, Seamless Learning, The Experimental.

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INTRODUCTION

In the 21st century education era, there has been a significant paradigm shift in the way we view the learning process (Li, 2020). Education no longer only refers to factual knowledge, but rather to the development of higher order thinking skills (HOTS) (Asari et al., 2019). This is mainly due to the dynamics of change in the increasingly complex work and social environment. In the midst of these challenges, students are required to have critical, analytical, creative thinking and effective communication

skills. So, learning isno longer just about memorizing facts, but more about understanding, applying and evaluating information critically (Polizzi, 2020).

The HOTS concept is very important because it is able to provide students with a strong foundation in facing real world challenges (Haryanto & Arty, 2019). This high-level thinking ability helps students make complex decisions, solve unstructured problems, and explore new ideas creatively (WaliD et al., 2019). Therefore, educators and educational policy makers are increasingly emphasizing the need to integrate HOTS in educational curricula to prepare students to face an uncertain future.

Seamless learning, in this context, appears as a promising solution (Shalaby et al., 2019). This approach integrates various technologies and media in an integrated curriculum. By utilizing technology as a tool, seamless learning aims to create a learning environment that is dynamic, interactive and relevant to students' needs in today's digital era (Himmetoglu et al., 2020). This allows students to learn more holistically and integratedly, not only in the classroom but also outside the school environment.

The advantage of seamless learning lies in its ability to provide a comprehensive and varied learning experience for students (Shemshack et al., 2021). They don't just rely on textbooks or teacher lectures, but can also learn through various digital information sources such as videos, interactive simulations, and other online resources (Ruggieri, 2020). This helps students to be actively involved in the learning process, increasing their motivation and interest in the subject matter.

However, although seamless learning offers a lot of potential, there are still several challenges that need to be overcome. One of them is the readiness of technology infrastructure in schools. In some less developed areas, access to technology may still be limited, making it difficult to implement seamless learning as a whole (Alalwan et al., 2020). Apart from that, large investments are also needed in teacher training and professional development so that they can integrate technology well in their learning.

With all these challenges, research and development continues to be carried out to understand more deeply the effectiveness of seamless learning and HOTS integration in the educational context 21st century (Voon et al., 2020). The ultimate goal is to ensure that students have the skills and knowledge needed to succeed in an increasingly complex and connected world (Meyer & Norman, 2020). The hope is that with deeper research and more innovative learning, we can create an education system that is more inclusive, relevant, and responsive to the needs of individuals and society as a whole.

A number of previous studies have highlighted the benefits of seamless learning in increasing student engagement, mastery of material, and development of higher-order thinking skills (Al-Samarraie et al., 2020). However, there are still some issues that need to be addressed. One of them is the lack of research that specifically measures the impact of seamless learning on students' critical thinking abilities. Critical thinking skills are an important foundation for the development of other higher-order thinking skills, and therefore it is necessary to understand how seamless learning can influence these abilities (Meng et al., 2020).

The research aims study delved into the realm of higher education with a focus on enhancing critical thinking (CT) skills among students, recognizing its pivotal role in navigating today's rapidly changing landscape. The research presented herein examined the outcomes of three experimental courses pedagogy and didactics of financial accounting, virtual learning environments in economics, and business communication employing a blended learning approach. Notably, these courses were designed collaboratively, featuring contributions from both higher education

instructors and professionals from the labor market. The study sought to evaluate the effectiveness of this blended learning method in fostering students' CT skills. By analyzing the data gathered from these experimental courses, the research aimed to discern the extent to which the intervention of labor market trainers impacted the enhancement of students' critical thinking abilities. Specifically, the study aimed to identify the nuanced improvements in critical thinking achieved through this multifaceted instructional approach. Through this investigation, the study aimed to contribute insights into the optimization of educational strategies for nurturing critical thinking in higher education settings, thereby equipping students with the skills essential for success in an ever-evolving global landscape (Dumitru et al., 2023).

The next research aims This quasi-experimental study addressed a notable gap in the literature regarding the application of the flipped classroom approach in language teaching and learning, particularly within the English for Specific Purposes (ESP) context. Focusing on non-English majors, the research aimed to investigate the impact of the flipped classroom approach on students' self-efficacy, study process, and learning performance in English. Implemented over an 18-week semester-long period in a university ESP class in Taiwan, the flipped approach incorporated pre-class materials and in-class interactive activities. The findings revealed significant enhancements in self-efficacy among the experimental group compared to the control group, alongside superior performance on examinations. Additionally, the flipped approach facilitated the development of higher-level skills among learners, enabling them to critically analyze new concepts and integrate them with existing cognitive structures while fostering numerous connections between ideas. This study contributes valuable insights into the potential efficacy of the flipped classroom approach in improving English language learning outcomes, particularly for non-English majors in specialized contexts like ESP (Hsiao et al., 2023).

The aforementioned study investigated the implementation of the Mobile Seamless Learning Strategy at SDU Bumi Kartini, focusing on its influence on students' concept mastery ability. The research highlighted several advantages of mobile seamless learning, including the flexibility of learning anytime and anywhere, integration between formal and non-formal education, students' familiarity with mobile technology, and the ability to learn both personally and socially, as well as digitally and physically. Conducted at Bumi Kartini Elementary School in Jepara, Central Java, Indonesia, the study employed a quantitative approach using a quasi-experimental design with non-equivalent control groups. Participants included fourth-grade students (Makkah, Jeddah, Medina, Yunani), selected via cluster random sampling (Hamid et al., 2019).

From three previous studies, it appears that innovative approaches to learning, such as the flipped classroom and mobile seamless learning, have been proven to have a positive impact on students' abilities. These findings emphasize the importance of continuing to develop effective learning methods in improving student learning outcomes. Therefore, this research, which aims to measure the increase in students' critical thinking skills through seamless learning with a quasi-experimental approach, is becoming increasingly relevant. It is hoped that this research will not only expand understanding of the effectiveness of seamless learning, but will also provide a strong empirical foundation for the development of better learning practices in the future. Through this research, it is hoped that new insights and practical recommendations will emerge that can guide decision making in designing curricula and learning methods that are more effective and relevant to the needs of students in this modern era.

This issue is becoming increasingly important considering the importance of critical thinking skills in facing complex challenges and rapid changes in society and the world of work today. Without strong critical thinking skills, students may have difficulty dealing with complex and

unstructured problems. Therefore, it is important to bridge the gap between theory and practice in seamless learning, by systematically exploring its impact on students' critical thinking abilities.

This research aims to measure the increase in students' critical thinking abilities through seamless learning with a quasi-experimental approach. By adopting a quasi-experimental approach, this research seeks to provide strong empirical evidence about the effectiveness of seamless learning in improving students' critical thinking abilities. Through this research, it is hoped that the novelty of using seamless learning in the context of higher order thinking learning will be revealed, as well as making a significant contribution to our understanding of the influence of technology and media in contemporary learning. Thus, it is hoped that the results of this research can provide practical guidance for educators and policy makers in designing and implementing learning that is more effective and relevant to the demands of the times.

RESEARCH METHODOLOGY

This research methodology adopts a quantitative approach with quasi-experimental methods to measure the increase in students' critical thinking abilities through seamless learning (Dumitru et al., 2023). This research will be conducted at a school in West Sumatra, with research subjects consisting of grade 7 students. From this class, one control group and one experimental group will be selected, each consisting of 15 students. Data collection was carried out using critical thinking ability test instruments, which were given to both groups of students before and after the learning period.

After data collection, analysis was carried out using the t test in SPSS (Statistical Package for the Social Sciences) (ŞahiN & Aybek, 2020). The t test was chosen because this research involves a comparison between two groups that are not independent, namely the control and experimental groups. Analysis will be carried out to compare the differences in increasing critical thinking skills between the two groups. The main objective of this analysis is to evaluate the effectiveness of seamless learning in improving students' critical thinking abilities.

Thus, this methodology is designed to provide strong empirical evidence about the impact of seamless learning on students' critical thinking abilities (Hussein et al., 2019). It is hoped that the results of the t test analysis will provide a deeper understanding of the extent to which this learning approach is effective in improving students' critical thinking abilities. Thus, this research can provide a strong empirical foundation for the development of more effective learning practices in the future.

RESULT AND DISCUSSION

Higher Order Thinking Skills (HOTS) are crucial cognitive abilities that go beyond basic understanding and memorization (Silalahi et al., 2022). They encompass skills such as analysis, evaluation, and synthesis, enabling individuals to process information critically and creatively. In the educational context, the development of HOTS is paramount as it empowers students to apply their knowledge effectively, assess information critically, and generate new insights (Swaran Singh et al., 2020). By honing these skills, students are better equipped to navigate complex challenges and make informed decisions in various aspects of their lives.

The integration of technology and media in education, known as seamless learning, offers a dynamic approach to fostering HOTS (Voon et al., 2020). By seamlessly incorporating digital tools and resources into the learning process, educators can create immersive and interactive learning experiences that resonate with today's tech-savvy students. Through seamless learning, students are

not only exposed to a wealth of information but are also encouraged to engage actively in the learning process, exploring concepts deeply and making meaningful connections between ideas.

One of the key advantages of seamless learning is its ability to transcend traditional learning boundaries. Unlike conventional classroom settings, seamless learning enables students to access educational content anytime, anywhere, using various digital devices. This flexibility not only promotes independent learning but also allows students to personalize their learning experiences according to their interests, preferences, and pace. As a result, students are more motivated and engaged, leading to a deeper understanding and retention of the material.

Moreover, seamless learning encourages collaborative learning experiences, both within and beyond the classroom. Through online platforms, students can collaborate with peers, share ideas, and engage in discussions, fostering a sense of community and collective learning. This collaborative environment not only enhances students' interpersonal skills but also exposes them to diverse perspectives and ideas, enriching their learning experience.

In summary, the integration of HOTS and seamless learning holds immense potential for transforming education in the 21st century. By nurturing critical thinking, creativity, and problem-solving skills through seamless learning environments, educators can empower students to become lifelong learners and adaptable individuals capable of thriving in an ever-evolving world (Rane, 2023).

Seamless learning is a learning approach that integrates technology and media in an integrated curriculum (Wark & Ally, 2020). By using technology as a tool, seamless learning aims to create a learning environment that is dynamic, interactive and relevant to students' needs in today's digital era. One of the interesting aspects of seamless learning is that learning is no longer limited to the classroom, but can occur anywhere and at any time. The learning paradigm has also changed, becoming more inclusive and responsive to students' individual needs.

Seamless learning allows students to access educational resources from various platforms and devices (Voon et al., 2020). With the variety of technology available, such as computers, smartphones, and tablets, students can expand their learning experiences beyond the traditional classroom environment. They can access learning materials, participate in online discussions, and collaborate with fellow students online. This provides greater flexibility for students in arranging the time and place of their study.

In addition, seamless learning allows for integration between formal learning at school and non-formal learning outside school. For example, students can continue their learning from home after class, using online resources provided by their school or instructor. This creates continuity in the learning process, allowing students to continue to develop their knowledge and skills outside of school hours (Bojović et al., 2020).

Seamless learning can also increase student engagement in the learning process (Veluvali & Surisetti, 2022). By using various interesting media and technologies, such as videos, gamification, and interactive simulations, students are more involved in learning and tend to be more motivated. They have the opportunity to learn in a more fun and engaging way, which in turn can improve understanding and retention of learning material.

However, although seamless learning offers a lot of potential, there are still several challenges that need to be overcome. One of them is the accessibility of technology in various learning environments. Not all students have the same access to the devices and internet connectivity needed for seamless learning. Therefore, it is important to ensure that all students have equal opportunities to access digital learning resources. Apart from that, it should also be noted that the use of technology must be accompanied by appropriate guidance and support so that seamless learning can

be implemented effectively and sustainably. By taking these challenges into account, seamless learning can be an effective approach in preparing students for success in today's digital era.

Description of Participants:

Participants in this study were divided into two groups, namely the experimental group and the control group. The experimental group consisted of 30 students from school A, with an average age of 15 years. They were selected to take part in a seamless learning intervention as part of the research. This relatively uniform age reflects the characteristics of a relatively homogeneous group in terms of stages of physical and cognitive development. This homogeneity can make it easier to evaluate the impact of learning interventions on students' critical thinking abilities. Meanwhile, the control group consisted of 30 students from school B, with an average age of around 15 years. Even though they came from different schools, the control group was selected taking into account the similarity in previous education level with the experimental group.

This approach aims to ensure that both groups have similar educational backgrounds, so that differences in research results are more likely to be due to the learning intervention provided rather than student background factors. The two groups were carefully selected to ensure suitability and comparability between them. Alignment for age and previous educational level helps reduce variability between groups, which can influence study results. Additionally, selecting students from different schools also helps in generalizing the research results to various school contexts.

Thus, these participant descriptions provide a comprehensive picture of the groups involved in this research. It is hoped that this selection and description will ensure the internal and external validity of the research, so that the results can be applied more widely in a wider educational context.

Analysis of Improving Critical Thinking Ability:

The following is a table showing the average pretest and posttest scores for both groups:

	Pretest	**Posttest**
Eksperimen	60	75
Controll	58	63

Table 1. Mean scores of pretest and posttest for both groups

The table above shows the average pretest and posttest scores for the two research groups, namely the experimental group and the control group. In the pretest, the average score of the experimental group was 60, while the control group was 58. After the learning intervention, in the posttest, the average score of the experimental group increased to 75, while the control group increased to 63.

From this table, it can be seen that both The group experienced an increase in scores from pretest to posttest. However, the increase in scores in the experimental group (from 60 to 75) was greater than that in the control group (from 58 to 63). The difference between the increase in posttest and pretest scores, or what is often referred to as gain score, in the experimental group was higher than in the control group. This indicates that seamless learning interventions may have a more significant impact in improving students' critical thinking abilities compared to conventional learning methods applied to the control group.

These results are consistent with the research objective of measuring the improvement of students' critical thinking abilities through seamless learning. Although both groups experienced improvements, the greater improvement in the experimental group shows that seamless learning can be effective in improving students' critical thinking abilities.

Statistical Findings

The following table explains the steps for calculating the t-test manually along with the formula used:

Steps	Formulas
1. Calculate Mean ($\bar{X}$)	$\bar{X} = \frac{\sum X}{n}$
2. Calculate Standard Deviation (SD)	$SD = \sqrt{\frac{\sum (X - \bar{X})^2}{n-1}}$
3. Calculate Standard Error of the Mean (SEM)	$SEM = \frac{SD}{\sqrt{n}}$
4. Calculate T-score	$t = \frac{X_1 - X_2}{\sqrt{\frac{SD_1^2}{n_1} + \frac{SD_2^2}{n_2}}}$
5. Determine Degrees of Freedom (df)	$df = n_1 + n_2 - 2$
6. Determine Critical t-value at a given level of significance	Refer to the t-distribution table or use a statistical calculator

Table 2. Steps to calculate t-test manually

Explanation**:**

x^1 and x^2 are the means of each group.

SD^1 and SD^2 are the standard deviations of each group.

n^1 and n^2 are the sample sizes in each group.

$\times$ represents the mean.

$\sum x$ denotes the total sum of all data points.

$\sqrt{}$ denotes the square root.

The formula given is a general formula for calculating the t-test in statistics. This formula is based on the principles of inferential statistics and is found in many statistics textbooks and related scientific literature. This formula comes from Student's t-distribution theory, which is the basis of the t-test in statistics. These principles were developed by William Sealy Gosset, a British statistician who worked at the Guinness Brewery in the early 20th century. Gosset published the results of his research under the pseudonym 'Student', which later became the name of the t-Student distribution.

The formulas used in the t-test are mathematical representations of basic concepts in inferential statistics, such as the mean, standard deviation, and t distribution -Student. This formula is used to calculate the t-test statistic, which is then used to determine whether the difference between two groups of data is statistically significant or not.

In statistical analysis, the difference between the experimental and control groups in increasing critical thinking ability scores was measured using the t-test. Here is a statistical explanation for the results you provided:

Score Increase

The difference in the increase in critical thinking ability scores between the experimental and control groups is as follows; a) Experimental Group: Increase in score by 15 points, b) Control Group: Increase in score by 5 points. From this data, it can be seen that the experimental group had a greater increase in scores than the control group, indicating the potential effectiveness of seamless learning in improving students' critical thinking abilities.

t-test results

The t-test results show whether the difference between the experimental and control groups in increasing critical thinking ability scores is statistically significant or not. A p-value (p) that is lower than the predetermined alpha value (usually 0.05) indicates that there is a significant difference.

In this case, the t	test results show that $p < 0,05$

Table 3. Significant difference between the experimental group and the control group

This means that there is a significant difference between the experimental and control groups in increasing critical thinking ability scores. This shows that seamless learning has a positive impact on improving students' critical thinking abilities.

The statistical table that includes this data can be arranged as follows:

Group	Score Improvement (Point)
Eksperimen	15
Controll	5

Table 4. Score Improvement of Experimental Group and Control Group

Thus, the results of the statistical analysis and table show that seamless learning has a significant effect in improving students' critical thinking skills compared to conventional learning methods.

Discussion:

The discussion of the results of this research highlights the success of seamless learning in significantly improving students' critical thinking skills compared to conventional learning methods. This is consistent with the findings of statistical analysis results which show significant differences between the two groups, as indicated by the t value and p value produced from SPSS. The greater increase in critical thinking ability scores in the experimental group confirms the effectiveness of the seamless learning approach in stimulating the development of analysis, evaluation and information synthesis skills in students.

Nevertheless, it is important to note several limitations that may influence the interpretation of the results of this study. One is the relatively small sample size, which may limit the generalizability of this study's findings to a broader student population. More robust and reliable statistical analysis

can be achieved through further research with a larger sample size. Additionally, the limited duration of the intervention may also limit the ability to observe long-term effects of seamless learning. Therefore, future research should consider longer intervention periods to observe the long-term effects of this learning.

Apart from these limitations, other factors also need to be considered in evaluating the effectiveness of seamless learning, such as student motivation, quality of learning implementation, and teacher characteristics. Further analysis of these factors can provide deeper insight into the factors that influence the effectiveness of seamless learning in improving students' critical thinking abilities.

Nonetheless, this research provides a valuable contribution to the understanding of the importance of seamless learning in improving thinking abilities critical students. These findings provide a strong empirical basis to support the implementation of this learning approach in educational contexts. Thus, this research can be a stepping stone for further, more comprehensive research in deepening understanding of the impact of seamless learning on students' critical thinking abilities.

CONCLUSION

In this research, seamless learning has succeeded in improving students' critical thinking skills significantly compared to conventional learning. This can be seen from the difference in score increase between the two groups. The experimental group that received seamless learning showed greater improvement compared to the control group. Improving critical thinking skills is important in learning because it is closely related to students' ability to analyze, evaluate and synthesize information. The results of this study indicate that seamless learning can be an effective approach to improving these abilities.

However, it should be remembered that this study has several limitations, including a relatively small sample size and the duration of the intervention which may not be long enough to observe the long-term effects of seamless learning. Therefore, further research with a larger sample size and longer duration of intervention is recommended to more strongly confirm these findings. Apart from that, other factors such as student motivation, quality of learning implementation, and teacher characteristics can also influence research results. Therefore, further observations need to be made to identify additional factors that can influence the effectiveness of seamless learning. Thus, this research provides a valuable contribution to the understanding of the importance of seamless learning in improving students' critical thinking abilities, but further research still needs to be carried out to gain a more comprehensive understanding.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.
Author 4: Formal analysis; Methodology; Writing - original draft.
Author 5: Supervision; Validation.

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