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RESEARCH ARTICLE

Effectiveness of Collaborative Learning Using an Artificial Intellegence-Based Learning Management System (LMS) to Enhance Scientific Literacy Skill for Early Childhood Education Teacher Candidates

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ABSTRACT

This study aims to analyze the effectiveness of using a collaborative learning model using a learning management system (LMS) based artificial intellegence to enhance scientific literacy skill. The research employs a quantitative approach with a quasi-experimental method involving two classes: an experimental class and a control class. The experimental class uses a collaborative learning model integrated with LMS, while the control class employs conventional teaching methods. The participants of the study consist of 108 students from the Early Childhood Education Teacher Education Study Program at Universitas PGRI Argopuro Jember, randomly selected through cluster random sampling techniques. The experimental group consists of 54 students, and the control group also comprises 54 students. Data were collected through pretests and posttests related to the Science Literacy, which were then analyzed using normality tests, homogeneity tests, t-tests, and N-gain tests to measure learning effectiveness. The results indicate that the average posttest score in the experimental class (81.69) is significantly higher than that of the control class (68.13), with a t-test probability value of 0.001 (< 0.05), indicating a significant difference between the two groups. The N-gain test results show an effectiveness value of 1.14, meaning that the collaborative learning model using LMS based artificial intellegence is more effective than conventional learning.

INTRODUCTION

Collaborative learning has become one of the recognized approaches in the field of education to enhance student engagement and interaction. Collaborative learning focuses on cooperation among students in completing tasks, where each individual contributes to achieving common goals [1][2]. This facilitates the process of sharing knowledge and skills among students, ultimately deepening their understanding of academic concepts [3][4].

The use of a learning model with a classroom setting that facilitates small group discussions has become a sufficiently adequate alternative solution [5]. Collaborative learning can encourage improvements in academic outcomes as well as the quality of students' social interactions [6]. It enhances critical thinking through discussions, clarification of ideas, and evaluation of others' ideas [7]. The implementation of the collaborative learning model provides broader opportunities for students to be more active in the classroom learning process, as it emphasizes student discussions and active engagement with the provided material [8]. The fundamental principle underlying collaborative learning is mutual learning and sharing, ensuring that no student excels alone and no student is left behind in this learning model [9].

The use of Learning Management Systems (LMS) in education has rapidly developed over the past few decades, especially with the increasing adoption of digital technology in the learning process. LMS, which is essentially an online platform that facilitates the management, distribution, and evaluation of learning, has become a primary solution in addressing the challenges of distance and blended learning [10][11][12]. In Indonesia, the COVID-19 pandemic has accelerated the use of LMS at various educational levels, including higher education, in response to the need for effective learning even when conducted online [13][14]. LMS offers various features that support interaction between instructors and students, such as discussion forums, assignment submissions, online quizzes, and the provision of structured learning materials. With LMS, students have more flexible access to learning materials, while instructors can more easily monitor students' progress and engagement. This is expected to enhance the quality of learning and facilitate better learning outcomes.

However, the effectiveness of using LMS in learning greatly depends on various factors, such as the readiness of instructors and students, adequate technological infrastructure, and the pedagogical approaches applied in utilizing the platform. In several educational institutions in Indonesia, the challenges faced in the implementation of LMS include limited internet access, lack of training for instructors, and minimal meaningful interaction between students and instructors in the online learning environment [15].

The use of LMS in learning has shown a positive impact on student engagement, especially in the context of online learning [16][17]. LMS provides various features that allow students to collaborate, such as discussion forums, group assignments, and online chat rooms. Thus, the integration of collaborative learning and LMS can create a more dynamic and interactive learning environment that supports the mastery of complex scientific concepts.

Mastery of scientific concepts is an important aspect of higher education, especially for students pursuing programs in the field of science. A good understanding of scientific concepts enables students to grasp the fundamental principles that form the foundation of the disciplines they study. However, challenges in mastering scientific concepts in Indonesia remain a serious concern. Various studies indicate that students often struggle to comprehend abstract and complex scientific concepts [18][19][20]. Factors such as limited facilities and infrastructure, the quality of teaching, and less innovative learning approaches also contribute to the low mastery of scientific concepts among students in Indonesia [21][22].

The quality of science education in Indonesia generally still faces significant challenges, as reflected in the results of the Program for International Student Assessment (PISA) study. In the PISA report, Indonesia's science performance ranks unsatisfactorily compared to other countries [23]. Although the PISA data primarily focuses on secondary school students, it provides a general overview of the challenges in science education in Indonesia, including at the higher education level [24][25].

A Learning Management System (LMS) is an integrated online learning management system and a technological advancement that can be utilized as a support in the learning process [26][27][28]. The development of AI-based Learning Management Systems represents a new breakthrough in the field of Education, with the aim of creating personalized learning experiences tailored to students' learning styles [29]. This is expected to serve as a foundation for the formation of student groups (collaborative learning) based on their learning styles and interests [30][31].

In the continuously evolving era of educational innovation, the use of Information and Communication Technology has brought a significant revolution for educators, including professors, in determining the teaching strategies to be employed [32]. Amidst these changes, the utilization of AI-based Learning Management Systems (LMS) has opened intriguing new opportunities to enhance scientific literacy. One of the groups that benefits the most from this approach is students majoring in teacher education, who are future teachers.

Efforts to enhance scientific literacy among prospective teacher candidates can be achieved by implementing collaborative learning strategies, with AI-based LMS playing a pivotal role in its realization. This collaborative learning approach involves active interaction and cooperation among

students, collectively fostering a deeper understanding of fundamental scientific concepts as well as the development of critical thinking skills [33][34].

AI based LMS enables efficient and effective engagement in group learning strategies [35]. Intelligent AI features, such as adaptive learning analysis, recognition of learning patterns, and personalized material recommendations, aid in mapping individual and group progress in real-time [36]. As students collaborate within groups, the LMS utilizes the collected data to provide relevant feedback, design additional activities to deepen understanding, or offer specific guidance required by each group member [37][38]. Additionally, AI based LMS facilitates improved communication and more intense collaboration among group members. This platform enables online discussions, idea exchanges, and resource sharing, overcoming time and physical space limitations. Prospective teacher candidates can support one another, collectively solve problems, and enhance their creativity in analyzing learning situations [39].

The novelty of this research lies in its focused development of a learning management system (LMS) with AI based features to predict students' learning styles and facilitate the formation of study groups. Additionally, the use of collaborative learning provides students with a platform to interact and discuss with their peers. This study also emphasizes the implementation of digital learning through the LMS developed, utilizing a collaborative learning approach, which is expected to enhance students' scientific literacy. As a result, this research stands out with its distinctiveness, as it combines AI technology and collaborative learning to enhance students' scientific literacy, offering a significant contribution to the future development of digital learning.

2. RESEARCH METHOD

The approach used in this study is a quantitative research approach. Quantitative research is a type of research that generally employs statistical analysis [40]. The type of research chosen for this study is Quasi-Experimental Research. The design used for this research is the nonequivalent control group design, where there are two groups: the experimental group that receives learning using collaborative learning using an AI based LMS, and the control group that uses conventional learning. This design allows the researcher to compare the results between the two groups to see the effectiveness of the applied learning model [41].

Table 1: Research design

Group	Pretest	Treatment	Posttest
Experiment	R_1	X_1	R_2
Control	R_3	X_2	R_4

Notes (Table 1):
R_1: Pretest of in the experiment group
R_2: Posttest of Scientific Literacy in the experiment group
R_3: Pretest of Scientific Literacy in the control group
R_4: Posttest of Scientific Literacy in the control group
X_1: Treatment using collaborative learning using an artificial intellegence-based LMS in the experiment group
X_2: Treatment using a conventional model in the control group

The participants in this study are students from the Early Childhood Education Teacher Education Program at Universitas PGRI Argopuro Jember, Indonesia, who were selected using cluster random sampling, a regional sampling technique used to determine samples when the objects to be studied or data sources are extensive [42]. Out of a total population of 260 students, 108 participants were chosen and divided into an experimental group consisting of 54 students and a control group also consisting of 54 students. The data collection method in this study utilized tests comprising 5 open-ended questions to obtain data related to students' Science Literacy. Data analysis methods included prerequisite tests for normality and homogeneity, followed by an Independent Sample T Test and N-gain tests [43][44].

3. RESULTS

In this study, the initial data was obtained from the pretest data administered to assess the students' initial scientific literacy before implementing collaborative learning using an AI-based LMS. The pretest was given to both the experiment and control group. The final data obtained was in the form of a posttest, which served as the measure of students' scientific literacy after applying collaborative learning using an AI-based LMS. The posttest was also administered to both the experimental and control groups. The results obtained are presented in the descriptive data recap shown in Table 2.

Table 2: Recap of descriptive data for students' pretest and posttest scores

Group	Avarage Pretest	Avarage Posttest
Control	48,94	68,13
Experiment	47,89	81,69

Table 2 shows the average pretest score for scientific literacy in the control class is 48.94, and the average posttest score for scientific literacy in the control class is 68.13. Meanwhile, the average pretest score for scientific literacy in the experiment group is 47.89, and the average posttest score for scientific literacy in the experiment group is 81.69.
Normality testing was conducted using the Shapiro-Wilk test, with calculations performed using SPSS 26 software. If the Sig value is greater than 0.05, the data is considered normal; otherwise, it is deemed not normal. This test is used to determine whether the obtained data is normally distributed or not. The results of the normality test calculations for the essay test can be seen in Table 3.

Table 3: Results of the normality test for pretest and posttest

Group	Shapiro Wilk (Pretest)	Shapiro Wilk (Posttest)
Control	0,061	0,184
Experiment	0,065	0,058

Table 3 shows that the results of the normality test for the control and experiment groups have a Sig value > 0.05. Therefore, it can be concluded that these data groups are normally distributed.
The homogeneity test is conducted to determine whether the data from both research samples have homogeneous or heterogeneous variances. If the Sig value > 0.05, it is stated to be homogeneous; otherwise, it is considered non-homogeneous or heterogeneous. The results of the calculations obtained are as follows:

Table 4: Results of the homogeneity test for pretest and posttest

	Df1	Df2	Sig
Pretest	1	134	0,842
Posttest	1	134	0,146

Table 4 shows that the results of the homogeneity test have a Sig value > 0.05. Therefore, it can be concluded that the obtained data groups are homogeneous.
In this study, a hypothesis test was also conducted using the t-test to determine whether there is a difference in students' scientific literacy between the control group and the experimental group. If the Sig value > 0.05, it indicates that there is no difference in scientific literacy; otherwise, it indicates a difference in scientific literacy between the control group and the experiment group.

Table 5: Results of the Pretest t-test

	Sig (2-tailed)
Scientific Literacy	0,841

Table 5 shows the results of the t-test for the pretest, with a probability value of 0.841. Since the probability is 0.841 > 0.05, this indicates that there is no significant difference in the initial scientific literacy between the control and experiment groups.

Table 6: Posttest t-Test results

	Sig (2-tailed)
Scientific Literacy	0,001

Based on Table 6, the posttest t-test results showed a probability of 0.001. Since the probability value of 0.001 is less than 0.05, it can be concluded that there is a highly significant difference in the scientific literacy between the control group and the experiment group.
The N-gain test is used to evaluate and reinforce the effectiveness of the application of collaborative learning integrated with LMS. To interpret the N-gain score effectiveness values [45][46][47], refer to the following table:

Table 7: Categories of N-gain effectiveness interpretation

Percentage (%)	**Interpretation**
< 40	Ineffective
40 – 55	Less effective
56 – 75	Fairly effective
> 76	Effective

$$effectiveness = \frac{N - gain\ (experiment\ group)}{N - gain\ (control\ group)}$$

The criteria used to determine which learning method is more effective between collaborative learning using an AI-based LMS and conventional learning are as follows;

- If the effectiveness is > 1, it indicates a difference in effectiveness, where collaborative learning using an AI-based LMS is considered more effective than conventional learning.
- If the effectiveness is = 1, there is no difference in effectiveness between collaborative learning using an AI-based LMS and conventional learning.
- If the effectiveness is < 1, there is a difference in effectiveness where conventional learning is considered more effective than collaborative learning using an AI-based LMS.

Table 8 shows the results of the percentage N-gain values obtained through SPSS testing as follows:

Table 8: Results of the N-gain test

	Group	**Mean**	**Std. Error**
N-gain (%)	Control	70,5611	1,92079
	Experiment	80,5911	1,64537

Table 8 shows the results of the percent N-gain test, which yielded an average N-gain percentage. For the experimental group, the average was 80.59%, categorized as effective (see Table 7), while the average N-gain percentage for the control group was 70.56%, categorized as fairly effective (see Table 7).

$$effectiveness = \frac{80,59}{70,56}$$
$$effectiveness = 1,14$$

Based on the effectiveness testing criteria, the effectiveness test result was 1.14 > 1, which means there is a difference in effectiveness where learning with the collaborative learning model using an AI-based LMS is stated to be more effective in enhancing students' scientific literacy compared to learning with the conventional model.

4. DISCUSSION

The results gathered from this study involve pretest and posttest data on students' scientific literacy in two groups: the control group that followed conventional learning and the experimental group that implemented collaborative learning using an AI-based Learning Management System (LMS). The average pretest score in the control group was 48.94, which increased to 68.13 in the posttest. Meanwhile, the experimental group had an average pretest score of 47.89 and a posttest score of 81.69, indicating a greater improvement in scientific literacy compared to the control group. The homogeneity test (Sig > 0.05) showed that the distribution of scores in both groups was homogeneous or comparable. The pretest t-test resulted in a probability of 0.841 (> 0.05), indicating no initial difference in ability between the two groups. Conversely, the posttest t-test with a probability of 0.001 (< 0.05) showed a highly significant difference in scientific literacy between the two groups after the treatment.

The effectiveness of collaborative learning using an AI-based LMS is further evidenced by the effectiveness test result of 1.14, indicating that this method is highly effective (greater than 1) in enhancing scientific literacy. According to studies [48][49][50], technology-based approaches like LMS and AI have significant potential to boost student engagement and learning outcomes, particularly in facilitating collaborative interactions and broader access to educational resources. This aligns with the findings of this research, where the using an AI-based LMS allows students to access materials more flexibly, engage in deeper discussions, and reinforce their understanding of concepts through collaboration with classmates.

The discussion of this research results shows that the use of collaborative learning methods using an AI-based Learning Management Systems (LMS) is proven to be more effective in enhancing students' scientific literacy compared to conventional teaching methods. With a higher effectiveness score of 1.14, this study strengthens the argument that collaborative learning an AI-based LMS can facilitate interaction, access to materials, and the development of deeper conceptual understanding. This is highly relevant in the context of the rapidly evolving digital era, where education increasingly leverages technology as a primary means to support learning. Moreover, this research aligns with the paradigm shift in education during the digital age. Previous studies have suggested that technology in education can create interactive learning environments that support the development of critical understanding through richer and more varied media [51][52][53][54]. In this context, the use of LMS not only simplifies access to learning materials but also enables more intensive and meaningful collaborative processes, ultimately leading to positive learning outcomes. These findings reinforce the argument that educational technology, particularly through collaborative learning using an AI-based LMS, significantly contributes to improving students' learning outcomes, especially in mastering complex concepts such as science.

Other research also supports the finding that collaborative learning using an AI-based LMS, especially when collaborative in nature, has a significant impact on enhancing scientific literacy. Studies conducted by several researchers indicate that collaborative learning integrated with technology, such as LMS, increases student motivation [55][56][57][58]. LMS facilitates more dynamic interactions and provides various features like discussion forums, automatic assessments, and instant feedback, all of which contribute to increased engagement and better conceptual understanding. This is particularly evident in the results of this study, where students in the experiment group demonstrated a significant improvement in their scientific literacy.

Furthermore, previous research highlights that technology-supported collaboration helps students develop critical thinking skills and deeper understanding [59][60][61]. Collaborative learning facilitates more open and reflective discussions, allowing students to learn from their peers' perspectives. This is one reason why the experiment group in this study showed a greater improvement compared to the control group, which used conventional methods.

In addition, these findings are supported by studies conducted by previous researchers [62][63][64], which found that AI-based LMS technology provides a space for more personalized learning. LMS

allows students to access materials according to their needs and review challenging topics, which is not always possible in traditional face-to-face learning. This flexibility enhances deeper and more comprehensive understanding of concepts, as evidenced by the significantly higher posttest scores in the experiment group compared to the control group.

The conclusion drawn from various studies emphasizes that the use of AI-based LMS in collaborative learning not only provides flexibility in accessing materials but also promotes more meaningful and reflective interactions among students. This serves as strong evidence that technology-based learning, particularly through LMS, offers significant benefits in the context of modern education, where collaboration skills and deep conceptual understanding are becoming increasingly important [65][66][67].

Overall, these various studies indicate that AI-based LMS learning is not just a tool for delivering content, but also a platform that supports active engagement, effective collaboration, and the development of independent learning skills and deeper conceptual understanding [68]. This underscores that the use of LMS in collaborative learning has a significant positive impact on improving student learning outcomes, especially in mastering complex concepts such as science.

This study makes a significant contribution to the development of modern learning theory, particularly in understanding how collaborative learning used with technology can optimize student learning outcomes. The higher effectiveness results support the theory that using LMS in collaborative learning can enhance conceptual understanding more effectively than conventional methods. This research also provides practical guidelines for educators and educational institutions to adopt collaborative learning model using an AI-based LMS. With evidence of better effectiveness, instructors can design teaching strategies that leverage LMS to enhance interaction, collaboration, and deeper conceptual understanding. Educational institutions may consider broader integration of LMS across various learning programs. Additionally, the findings contribute to curriculum development in higher education, where LMS and collaborative learning can be incorporated as part of primary pedagogical strategies. The development of technology-based curricula allows students to have a more interactive and effective learning experience, adapting to the advancements in education during the digital age. Overall, this research not only contributes to the advancement of theory and practice in technology-based education but also serves as a foundation for innovation in learning design at higher education institutions.

5. CONCLUSION

The most important conclusion from this study is that collaborative learning using an AI-based Learning Management System (LMS) has proven to be more effective in enhancing students' scientific literacy understanding of science compared to conventional teaching methods. With a significant improvement in posttest results for the experimental class, this research emphasizes that the integration of technology and collaboration in learning can strengthen students' understanding of complex material.

The further implications for this field highlight the necessity for higher education institutions to consider broader using of Learning Management Systems (LMS), particularly for learning that requires deep conceptual understanding. This also opens up opportunities for developing more innovative and technology-based learning models to enhance student learning outcomes.

The benefits of this research lie in the empirical evidence supporting the effectiveness of Learning Management Systems (LMS) in education, particularly in the field of science. However, one limitation of this study is the restricted sample scope, which may affect the generalization of the results. Additionally, this research focuses solely on one area of study (science), meaning that the effectiveness of this method in other fields still requires further testing.

For future research, it is recommended that studies be conducted with a larger and more diverse sample, encompassing various disciplines to explore how LMS and collaborative methods can be adapted in different educational contexts. Further research could also investigate additional factors,

such as students' learning styles, levels of motivation, and digital skills, which may influence the effectiveness of collaborative learning using an AI-based LMS.

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