The Impact of Moodle LMS Integration on Group Discussions to Support Collaborative Learning

Ahmad Abtokhi
Faculty of Education and Teacher Learning, Universitas Islam Negeri Maulana Malik Ibrahim Malang
Malang, Indonesia
abtokhi@fis.uin-malang.ac.id

Hisyam Fahmi
Faculty of Science and Technology, Universitas Islam Negeri Maulana Malik Ibrahim Malang
Malang, Indonesia
hisyam.fahmi@uin-malang.ac.id

Mohammad Sholahuddin
Research and Service Center, Universitas Islam Negeri Maulana Malik Ibrahim Malang
Malang, Indonesia
sholahuddin@uin-malang.ac.id

***Abstract*—This study examines the implementation of collaborative learning in Basic Physics education through the utilization of Moodle Learning Management System (LMS). The investigation focuses on the impact of LMS integration on group discussions and problem-solving activities. Methods involved the random formation of 17 groups, consisting of 51 students, who engaged in both face-to-face and LMS-supported discussions. Group assessments were conducted, comparing pre-LMS and post-LMS usage scores, using two-tailed t-test analysis to determine differences in student performance. Results indicate that the incorporation of Moodle LMS in the collaborative learning process positively influenced group discussions and problem-solving outcomes, as evidenced by significant differences between pre-LMS and post-LMS scores. These findings highlight the potential of LMS integration to enhance collaborative learning experiences and improve student engagement in Basic Physics education.**

***Index Terms*—basic physics education, collaborative learning, group discussion, learning management system, Moodle**

I. Introduction

Learning Management Systems (LMS) have become integral tools in modern education, particularly in enhancing collaborative learning experiences in basic physics classes. Studies have shown that the utilization of LMS in educational settings, such as the Physics Education Department at Universitas Syiah Kuala, has been effective in managing classrooms, distributing course materials, and facilitating communication and collaborative activities [1]. The benefits of LMS implementation extend to efficiently circulating course materials, managing assignments, and enabling research activities [2]. Furthermore, the optimization of collaborative learning environments through LMS platforms has been highlighted as a method to enhance student engagement and interaction [3].

In the context of physics education, the use of LMS, such as Moodle, has been explored to boost creativity among candidate physics teachers and enhance their learning experiences [4]. Additionally, during challenging times like the Covid-19 pandemic, the Moodle LMS has been proposed as a framework to extend discourse classes and research activities, showcasing its adaptability and utility in diverse educational scenarios [5]. The effectiveness of collaborative team projects facilitated by LMS features like email and discussion boards has been linked to improved learning outcomes, emphasizing the role of LMS in fostering interactive and engaging learning environments [6].

Moreover, LMS platforms offer a range of features that support blended learning approaches, content management, assessment tools, and communication channels between instructors and students [7]. The integration of synchronous and asynchronous learning methods through LMS has been associated with increased student satisfaction and academic achievement, highlighting the versatility of LMS in catering to diverse learning preferences [8]. Additionally, the flipped classroom model, supported by LMS, has shown promise in enhancing academic achievement by delivering lectures through electronic means and promoting active student engagement [9].

In conclusion, the integration of LMS in basic physics classes has demonstrated significant potential in promoting collaborative learning, enhancing student engagement, and improving learning outcomes. By leveraging the features and capabilities of LMS platforms, educators can create dynamic and interactive learning environments that cater to the diverse needs of students in physics education.

II. Collaborative Features in Moodle

Moodle is one of LMS that has lot of functionalities and plugins to support the online learning process. To explore the features of Moodle that support collaborative learning, several studies provide insights into the functionalities of Moodle that enhance interaction and engagement among students and instructors. Aikina and Bolsunovskaya [10] highlighted that Moodle allows for course management, educational support, content distribution, and interaction among all involved parties, fostering a collaborative learning environment. Similarly, Silva and Peramunugamage [11] emphasized Moodle's features that enable course designers to embed and promote interactions between instructors and students, facilitating collaborative learning experiences. Moreover, Gamage et al. [12] found that

979-8-3503-8176-4/24/$31.00 ©2024 IEEE

Moodle is effective in improving student performance, satisfaction, and engagement within STEM disciplines, showcasing its supportive features for collaborative learning activities.

Additionally, Nalli et al. [13] identified features in Moodle that allow for the calculation of various aspects of the student learning process, such as presence coefficient, study coefficient, and activity coefficient, enhancing collaborative learning experiences. Hasan et al. [14] highlighted Moodle's flexibility and user-friendly interface, which contribute to the development of a gamified learning environment that promotes collaboration among students. Prasetya et al. [15] discussed how Moodle features like chat, forum, glossary, and wiki support collaboration and interaction among students in an online learning environment. In summary, Moodle's features such as course management, content distribution, interaction tools, gamification elements, and collaborative functionalities contribute to creating an engaging and interactive learning environment that supports collaborative learning activities among students and instructors. These features play a crucial role in fostering communication, collaboration, and knowledge sharing within the Moodle platform, enhancing the overall collaborative learning experience.

III. Collaborative Learning

Collaborative learning is an educational approach where students work together in groups to achieve a common academic goal. This method emphasizes active participation, shared responsibility, and mutual engagement among students, fostering a supportive and interactive learning environment. According to Vangrieken et al. [16], collaborative learning involves teachers working together to enhance the learning experience, with a focus on shared goals and cooperative efforts. Chi et al. [17] found that observing tutorial dialogues collaboratively can be as effective as individual tutoring, highlighting the importance of peer learning and collaboration in educational settings.

In collaborative learning, students learn by interacting with their peers, sharing knowledge, and collectively solving problems. Retnowati et al. [18] emphasized that collaborative learning occurs when students collaborate rather than study individually, promoting teamwork and communication skills. Features of Learning Management Systems like Moodle support collaborative learning by providing tools for communication, group work, and shared resources. For instance, Zhang et al. [19] proposed an optimized mechanism for improving online collaborative learning, considering cognitive load to enhance performance.

Collaborative learning strategies include various interaction methods, task types, and teacher involvement, as discussed by Gyasi et al. [20]. These strategies aim to promote active engagement, knowledge sharing, and effective communication among students. By implementing collaborative learning models, educators can create dynamic and interactive learning environments that enhance student participation and knowledge construction. Through collaborative learning, students can develop critical thinking skills, build social connections, and deepen their understanding of course material.

In summary, collaborative learning is a student-centered approach that encourages active engagement, peer interaction, and cooperative problem-solving. By leveraging collaborative learning methods and utilizing supportive technologies like Moodle, educators can create enriching learning experiences that promote teamwork, communication, and academic success among students.

IV. Methods

To conduct the analysis of the effectiveness of the Learning Management System (LMS) based on Moodle in supporting collaborative learning among basic physics students in higher education, a testing scenario has been outlined. The scenario involves several key components to achieve the research objective.

The methods description includes setting up and configuring the Moodle LMS platform for basic physics education, administering pre-assessment quizzes to gauge students' baseline knowledge, collecting demographic information, and assessing students' learning styles and attitudes towards collaborative learning.

A. Case Study Environment Setting

In the context of Basic Physics instruction, a combination of traditional face-to-face lectures and laboratory sessions is utilized. Within this particular study, the focus is on the problem-solving task, which takes place in a group-based setting involving a total of 51 students. To ensure randomization and diverse group compositions, these students are assigned to form 17 distinct groups. Each group is then given collaborative problem-solving assignments to work on collectively.

The assessment process involves two stages. The first stage serves as a pre-LMS usage assessment, where students participate in in-person discussions to address the given problems. This initial stage allows for face-to-face interactions and problem-solving discussions among group members, without the involvement of the LMS.

The second stage represents a post-LMS usage assessment, specifically during the discussion activity. In this stage, students from the same group are requested to discuss different problems within the same topic. To facilitate these discussions, the Moodle LMS platform is utilized, which provides a dedicated discussion feature for students to engage in online collaborative discourse.

It is important to note that this second stage serves as a post-LMS usage assessment, as students leverage the LMS to carry out their discussions. Therefore, it allows for an evaluation of the impact of LMS integration on the collaborative learning process.

Furthermore, within each group, individual student scores may vary based on their level of engagement and participation in the collaborative problem-solving process. This recognition acknowledges that students' contributions to the group's overall performance can differ, leading to variations in individual scores despite being part of the same group.

In order to reduce potential bias or imbalance in the results, the sample sizes of the different groups in the class experiment were not analyzed. Instead, an equal number of participants was assigned to each group. The possibility of unaccounted-for confounding variables is another drawback. Confounding variables are elements that are not specifically examined or controlled for in the study, but they may have an impact on how the independent and dependent variables relate to one another. These factors have the potential to add bias and compromise the reliability of the findings. Therefore, it is assumed that the confounding variables in this study have no effect on collaborative learning.

B. Evaluation

The evaluation component of this study aims to examine the influence of LMS utilization on group discussion activities designed to enhance Basic Physics learning. To assess this impact, a two-tailed paired t-test is employed to compare the learning outcomes of the groups before and after the incorporation of LMS. The null hypothesis states that there is no difference between the pre-test and post-test outcomes, while the alternative hypothesis suggests the existence of difference. The null hypothesis will be rejected if the calculated t-value exceeds the critical t-value or if the p-value falls below the predetermined significance threshold of 0.05, thereby indicating a significant distinction between the two experimental conditions.

In this case, we're interested in determining if there's a significant difference between the pre-test and post-test scores within each group. We want to ascertain if collaborative learning using LMS has any effect on the participants' performance, regardless of whether it improves or decreases their scores. Therefore, a two-tailed t-test is more appropriate because it allows us to detect any significant difference in either direction. Using a two-tailed t-test is more conservative as it spreads the significance level (α) equally across both tails of the distribution. This approach ensures that if the null hypothesis is rejected, it's based on stronger evidence, as it requires a more extreme test statistic to reach significance compared to a one-tailed test.

In this research, qualitative data was also collected to gather feedback from the participants regarding the LMS features. While the study did not primarily focus on using this qualitative data to support the analysis of collaborative learning, it aimed to capture the participants' perceptions and experiences with the LMS features specifically. However, it is important to note that the analysis and findings of this research primarily revolved around the impact of the LMS on collaborative learning, rather than solely relying on the qualitative data collected for assessing the LMS features.

V. Results

A. Collaborative Learning Setting

In Moodle, there are several modules utilized for collaborative learning, including group creation, discussion forums, chat, and group assignments. The group creation process is done using the Group self-selection feature in Moodle, with the random grouping setting where each group consists of three members, as shown in Fig. 1. This results in the formation of groups as depicted in Fig. 2. Then, two case studies are assigned to each group. The first case study is completed collaboratively without the assistance of the LMS, while the second case study is accomplished with the aid of various features within the Moodle LMS, such as discussion forums, chat, and collaborative answer submission. An example case study is provided that relates to the topic of Laws of Motion, with different cases illustrated as shown in Fig. 3.

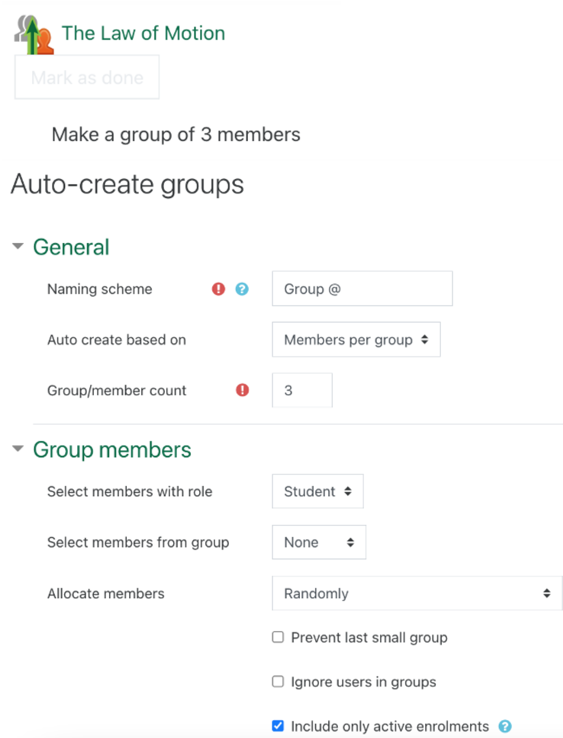

Fig. 1: The groups setting in the Moodle with random auto-create group.

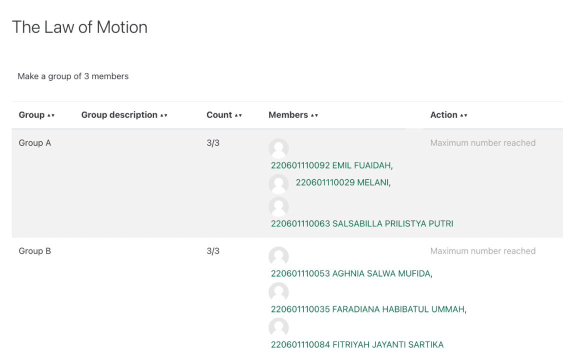

Fig. 2: Sample of grouping from previous setting.

The outcomes of the group work are evaluated, with the first case study serving as the pre-LMS test score and the second case study as the post-LMS usage test score. Subsequently, statistical analysis is conducted on the results of these group assessments to determine whether there are any differences before and after using the LMS.

Practice Problems on Newton's Second Law of Motion
We have provided you here with some practice problems Newton's Second Law of Motion.

Discuss with your group without using LMS module, for these problems:

Problem 1: A 5 kg object experiences a force of 20 N. Calculate the acceleration of the object.
Problem 2: A car with a mass of 1,200 kg accelerates at a rate of 3 m/s². What is the force applied to the car?
Problem 3: If you push a 50 kg box with a force of 200 N, what will be the acceleration of the box?
Problem 4: An astronaut with a mass of 70 kg is on the Moon, where gravity is about 1/6th that of Earth's. Calculate the astronaut's weight on the Moon and the force required to accelerate them at 5 m/s².
Problem 5: A rocket with a mass of 1,000 kg is launched into space. If it experiences a constant thrust force of 10,000 N, what will be its acceleration?

Write your group discussion answer in a piece of paper

(a) pre-LMS

Discuss with your group using LMS module in Moodle, for these problems:

Problem 1: A car with a mass of 800 kg accelerates at a rate of 4 m/s². What is the force applied to the car?
Problem 2: If you push a 30 kg box with a force of 150 N, what will be the acceleration of the box?
Problem 3: A 2 kg object experiences a force of 15 N. Calculate the acceleration of the object.
Problem 4: A rocket with a mass of 500 kg is launched into space. If it experiences a constant thrust force of 8,000 N, what will be its acceleration?
Problem 5: An astronaut with a mass of 60 kg is on the Moon, where gravity is about 1/6th that of Earth's. Calculate the astronaut's weight on the Moon and the force required to accelerate them at 3 m/s².

Submit your answer based on your group discussion to Moodle e-learning

(b) post-LMS

Fig. 3: Sample of problems given.

B. Class Testing Result

The Table I presents the pre and post-scores of 17 groups in a collaborative learning setting utilizing an LMS. The table is organized into three columns for each member within their respective group. Each member is identified by their gender, pre-score, and post-score. The participants in each groups consists of a mix of male and female participants, with pre-scores ranging from 78 to 98 and post-scores ranging from 80 to 98.

The box-plot in Fig. 4 displays the distribution of testing scores before and after the utilization of the LMS. It provides insights into the central tendency, spread, and outliers of the data. For the pre-LMS scores, the box extends from the lower quartile to the upper quartile, with the median score marked by a horizontal line within the box. The whiskers extend from the box to the minimum and maximum scores, indicating the range of the data. No outliers are present in this group.

In contrast, the post-LMS scores exhibit a higher median score compared to the pre-LMS scores. The box is slightly wider, indicating a slightly greater spread in the scores. There are a few outliers present, represented by individual points outside the box, suggesting some variability in the post-LMS scores.

Overall, the boxplot suggests that the utilization of the LMS positively influenced the testing scores, as indicated by the higher median score and the absence of outliers in the pre-LMS group, and the slightly wider spread and presence of outliers in the post-LMS group.

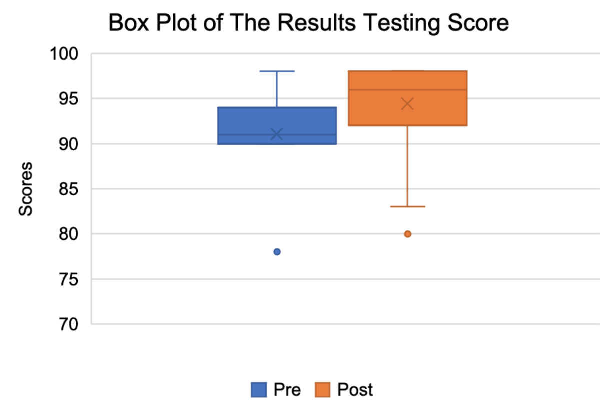

Fig. 4: Box plot of the testing results.

From the plot in Fig. 5, we can observe the mean scores for each group before and after the utilization of the LMS. The blue line represents the pre-LMS scores, while the orange line represents the post-LMS scores. Comparing the two lines, we can see a noticeable improvement in the post-LMS scores as shown in Table II. This indicates that the utilization of the LMS had a positive impact on the students' performance, as their scores increased after its implementation.

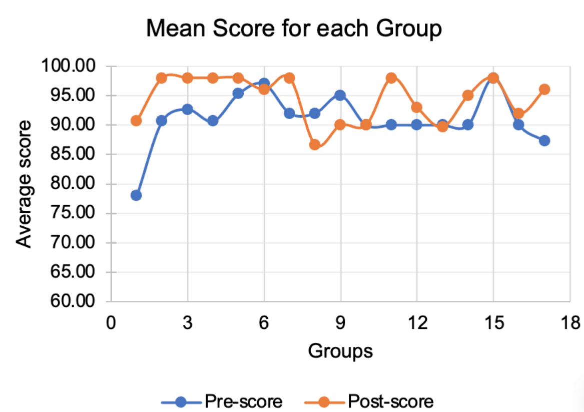

Fig. 5: Plot of pre and post-LMS utilization score.

C. Analysis

To perform a paired t-test on the given data, we compare the pre and post scores within each group. Then, we calculate the mean difference and standard deviation of the pre and post scores. After that, we can perform the two-tailed paired t-test to determine if the mean difference is statistically significant. Given the small sample size and the lack of assumptions about the population distribution, we use a paired t-test, which is appropriate for comparing the means of two related groups. Denote:

- $\bar{d}$ as the mean difference,

TABLE I: Pre and Post-scores of LMS Utilization in Group discussion

Group	Member 1			Member 2			Member 3		
	Gender	**Pre-score**	**Post-score**	**Gender**	**Pre-score**	**Post-score**	**Gender**	**Pre-score**	**Post-score**
1	F	78	88	F	78	92	F	78	92
2	F	90	98	M	92	98	F	90	98
3	F	92	98	F	92	98	M	94	98
4	F	91	98	F	91	98	F	90	98
5	F	95	98	F	96	98	F	95	98
6	M	98	96	F	96	96	F	97	96
7	F	92	98	F	92	98	F	92	98
8	M	92	90	M	92	90	M	92	80
9	M	95	90	F	95	90	F	95	90
10	M	90	90	F	90	90	F	90	90
11	F	90	98	M	90	98	F	90	98
12	F	90	93	M	90	93	F	90	93
13	F	90	93	M	90	83	F	90	93
14	M	90	95	F	90	95	F	90	95
15	F	98	98	M	98	98	F	98	98
16	M	90	92	F	90	92	F	90	92
17	M	92	98	M	92	98	F	78	92

TABLE II: Average of Pre and Post-LMS Scores

	Pre-score	**Post-score**
Mean	91.10	94.41
Stdev	4.42	3.86

- S_d as the standard deviation of the differences,
- n as the number of paired observations.

Then, calculate the t-value using the Equation 1.

$$t = \frac{\bar{d}}{\frac{S_d}{\sqrt{n}}} \tag{1}$$

Then, we compare the calculated t-value with the critical t-value at the desired significance level of 0.05. To calculate the t-value, we first need to find the mean difference ($\bar{d}$) and the standard deviation of the differences (S_d). Then, we'll use the Equation 1 to compute the t-value. After the calculation, we obtained $\bar{d} = 7.9706$, $S_d = 5.1155$, and $n = 17$. We can substitute these values into the formula:

$$t = \frac{7.9706}{\frac{5.1155}{\sqrt{17}}} \approx \frac{7.9706}{1.2412} \approx 6.42$$

Now, we compare this calculated t-value with the critical t-value at the desired significance level of 0.05 with degrees of freedom (df) equal to the number of paired observations minus 1 ($n-1$). Since $df = 16$, we can consult a t-distribution table or use statistical software to find the critical t-value. For a two-tailed test (since we're interested in both positive and negative deviations from the mean), the critical t-value is approximately ± 2.12.

After comparing the calculated t-value (6.42) with the critical t-value, we find that the calculated t-value is greater than the critical t-value with p-value $= 0.0132$). Therefore, we reject the null hypothesis and conclude that there is a significant difference between the pre and post scores within each group. In summary, collaborative learning using LMS has shown a statistically significant effect on the participants' performance, as evidenced by the differences between their pre and post scores.

D. Discussion

The results of the paired t-test indicate a significant difference between the pre-test and post-test scores within each group, demonstrating the effectiveness of collaborative learning through LMS in enhancing participants' performance. This finding aligns with previous research highlighting the positive influence of interactive and technology-mediated learning environments on student outcomes. The improvements observed in post-test scores suggest that LMS fosters a conducive learning atmosphere, aiding students in better understanding and retaining course material. Moreover, the significant variances across different groups highlight the adaptability of LMS in meeting diverse learning needs and preferences [21].

Nevertheless, it is crucial to recognize potential limitations, such as variations in sample sizes across groups and potential confounding variables not addressed in the analysis. Subsequent studies could delve into these factors further and incorporate additional measures to bolster the robustness of the results. Overall, the findings endorse the ongoing integration and enhancement of collaborative learning platforms like LMS in educational settings, emphasizing their role in fostering active engagement, knowledge retention, and academic achievement among students [21].

VI. Conclusion

The collaborative learning approach implemented in Basic Physics classes through LMS platforms like Moodle demonstrates a notable and positive impact on student performance, as indicated by the results of the paired t-test. These findings imply that LMS tools such as Moodle play a crucial role in fostering an enriching learning atmosphere that aids students in comprehending and retaining course content, ultimately leading to enhanced scores in post-tests. The adaptability of

LMS platforms becomes apparent through the significant differences observed across various student groups, showcasing their ability to cater to diverse learning styles and preferences. While advocating for the integration and refinement of collaborative learning methodologies via LMS, it's imperative to acknowledge potential limitations, such as variations in sample sizes and unaccounted confounding variables. Future research endeavors could explore deeper into these aspects to support the reliability of the findings and explore further into the effectiveness of collaborative learning utilizing LMS platforms like Moodle. In summary, this study emphasizes the pivotal role of LMS-driven collaborative learning in fostering student engagement, knowledge retention, and academic accomplishments. Educators can utilize the functionalities and features of LMS platforms to create interactive and dynamic learning environments that promote collaboration, communication, and overall effectiveness in achieving learning objectives.

ACKNOWLEDGMENT

The Ministry of Religious Affairs of the Republic of Indonesia provided funding for this study. The results of this study should help improve Indonesia's technology-based education.

REFERENCES

[1] E. Mahzum, H. Sofyan, M. F. Nasrudin, M. Mailizar, and F. Herliana, "Analysis of the utilization of the Learning Management System (LMS) as a learning media in the Physics Education Department Universitas Syiah Kuala," *Journal of Physics: Conference Series*, vol. 2596, p. 012070, sep 2023.

[2] A. Ekuase-Anwansedo, S. F. Craig, and J. Noguera, "How to survive a Learning Management System (LMS) implementation? A stakeholder analysis approach," in *Proceedings ACM SIGUCCS User Services Conference*, 2018.

[3] K. Tsujioka, "A Case Study of Using Big Data Processing in Education: Method of Matching Members by Optimizing Collaborative Learning Environment," in *Social Media and Machine Learning*, 2020.

[4] G. Gunawan, H. Sahidu, S. Susilawati, A. Harjono, and L. Herayanti, "Learning Management System with Moodle to Enhance Creativity of Candidate Physics Teacher," in *Journal of Physics: Conference Series*, vol. 1417, 2019.

[5] Sawirman, "The Use of Moodle Learning Management System to Extend Discourse Class and Research During the Covid-19 Pandemic," in *Proceedings of the 3rd International Conference on Educational Development and Quality Assurance (ICED-QA 2020)*, vol. 506, 2021.

[6] J. Costley, A. Southam, D. Bailey, and S. A. Haji, "How use of learning management system mediates the relationships between learner interactions and learner outcomes," *Interactive Technology and Smart Education*, vol. 19, no. 2, 2022.

[7] G. W. Wicaksono, G. A. Juliani, E. D. Wahyuni, Y. M. Cholily, H. W. Asrini, and Budiono, "Analysis of Learning Management System Features based on Indonesian Higher Education National Standards using the Feature-Oriented Domain Analysis," in *2020 8th International Conference on Information and Communication Technology, ICoICT 2020*, 2020.

[8] S. Z. M. Osman, "Combining Synchronous and Asynchronous Learning: Student Satisfaction with Online Learning using Learning Management Systems," *Journal of Education and e-Learning Research*, vol. 9, no. 3, 2022.

[9] N. I. Arshad, M. N. Abdullah, T. N. Z. Tengku Malim Busu, M. M Addi, N. I. Mokhtar, K. S. Kalid, and Savita K Sugathan, "Flipping the Classroom to Improve Academic Achievement of Information Systems Students with the Support of Learning Management System (LMS)," *Asean Journal of Engineering Education*, vol. 4, no. 2, 2021.

[10] T. Y. Aikina and L. M. Bolsunovskaya, "Moodle-based learning: Motivating and demotivating factors," *International Journal of Emerging Technologies in Learning*, vol. 15, no. 2, 2020.

[11] R. K. J. De Silva and A. Peramunugamage, "Emergency remote CAD teaching using licensed software in apparel during the COVID-19 pandemic: a collaborative learning approach," *Research in Learning Technology*, vol. 31, 2023.

[12] S. H. Gamage, J. R. Ayres, and M. B. Behrend, "A systematic review on trends in using Moodle for teaching and learning," 2022.

[13] G. Nalli, D. Amendola, A. Perali, and L. Mostarda, "Comparative analysis of clustering algorithms and moodle plugin for creation of student heterogeneous groups in online university courses," *Applied Sciences (Switzerland)*, vol. 11, no. 13, 2021.

[14] H. F. Hasan, M. Nat, and V. Z. Vanduhe, "Gamified Collaborative Environment in Moodle," *IEEE Access*, vol. 7, 2019.

[15] R. E. Prasetya, A. P. Pradipta, and G. Suratno, "Implementation Interactive and Collaborative Online Learning English for Foreign Language Moodle-based," *ETERNAL (English, Teaching, Learning, and Research Journal)*, vol. 8, no. 02, 2022.

[16] K. Vangrieken, F. Dochy, E. Raes, and E. Kyndt, "Teacher collaboration: A systematic review," 2015.

[17] M. T. Chi, M. Roy, and R. G. Hausmann, "Observing tutorial dialogues collaboratively: Insights about human tutoring effectiveness from vicarious learning," *Cognitive Science*, vol. 32, no. 2, 2008.

[18] E. Retnowati, P. Ayres, and J. Sweller, "Can collaborative learning improve the effectiveness of worked examples in learning mathematics?," *Journal of Educational Psychology*, vol. 109, no. 5, 2017.

[19] L. Zhang, X. Wang, T. He, and Z. Han, "A Data-Driven Optimized Mechanism for Improving Online Collaborative Learning: Taking Cognitive Load into Account," *International Journal of Environmental Research and Public Health*, vol. 19, no. 12, 2022.

[20] J. F. Gyasi, L. Zheng, and M. Long, "Reflecting on the past to shape the future: A systematic review on cross-cultural collaborative learning from 2011 to 2020," 2021.

[21] Z. Sun, R. Liu, L. Luo, M. Wu, and C. Shi, "Exploring collaborative learning effect in blended learning environments," *Journal of Computer Assisted Learning*, vol. 33, 2017.