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Analyzing Student Engagement through LMS Log Data in an Applied Statistics Course

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ABSTRACT

This study analyzes student engagement in an Applied Statistics course by integrating Learning Management System (LMS) activity logs, cognitive assessments, and student reflections. The primary objective is to investigate how behavioral engagement within a digital learning environment influences academic achievement. Employing a mixed-method approach descriptive qualitative supported by basic quantitative analysis this study collected data from five students through SPADA Unismuh LMS logs, pre-and post-tests, and semi-structured interviews. Quantitative findings show high engagement levels, with material access ranging from 47 to 51 times and forum participation between 7 and 8 times. These behaviors corresponded to substantial learning gains, with an average score increase exceeding 48%. Pearson correlation analysis revealed strong and significant relationships between LMS activity and academic improvement ($r = 0.88$ for material access; $r = 0.85$ for discussion participation). Qualitative insights indicated that multimedia-based materials (animations, infographics) and interactive forums enhanced comprehension of abstract concepts and fostered independent learning. By combining behavioral, cognitive, and experiential data, this study proposes a holistic framework for evaluating student engagement in digital learning. The findings contribute to the literature on learning analytics and offer practical guidance for enhancing engagement in small-class online learning environments.

1. Introduction

The development of digital technology has driven significant transformations in the world of education, particularly through the use of Learning Management Systems (LMS) as the primary platform for online learning. LMS provide essential features such as distribution of teaching materials, discussion forums, and real-time tracking of student activity, strengthening the technology-based learning ecosystem. In the

context of online learning, student engagement is a key indicator of the effectiveness of the learning process. This engagement can be tracked through LMS log data, which records the number of material accesses, duration of visits, and participation in discussion forums (Liu et al., 2025). To fully understand how students interact with digital learning environments, it is crucial to move beyond basic usage statistics and examine patterns of behavior over time. Several studies have shown that active engagement in an LMS is positively correlated with improved academic performance. Dimari et al. (2025) confirmed that utilizing LMS log data and adaptive learning systems can reduce academic anxiety and increase student learning motivation.

Furthermore, Fleck and Zhu (2024) demonstrated that learning strategies integrated into LMS forums significantly improve participation quality and exam performance. Therefore, LMS activity logs serve not only as administrative documentation but also as pedagogical analysis tools for evaluating learning effectiveness. Although the use of LMSs in online learning has become widespread, optimizing their use by students remains a challenge. Low participation in forums, inconsistent access to materials, and underutilization of LMS log data as an evaluative tool in learning are common. This indicates a gap between technology availability and user engagement. Furthermore, most evaluations still focus heavily on surface-level metrics without integrating students' cognitive and emotional engagement dimensions. An alternative approach combining LMS log analysis, learning outcome evaluation through pre- and post-tests, and in-depth interviews can provide a more comprehensive picture of student engagement. This triangulation approach can more holistically capture qualitative aspects such as student perceptions, motivations, and learning strategies. Such a comprehensive perspective is especially valuable in improving instructional design and providing timely interventions.

Research by Althaqafi et al. (2025) shows that an LMS based learning model that combines digital engagement with social interaction can improve the prediction of student academic performance. The application of data enrichment techniques such as SMOTE clarifies the relationship between student engagement and academic achievement. Zandvakili et al. (2024) highlight the importance of frequency of access and discussion participation as indicators of engagement and state that LMS activity logs can be used as valid, evidence-based data in learning evaluations. Furthermore, Fleck and Zhu (2024) emphasize that the quality of interactions in LMS forums is more important than the number of contributions. Furthermore, they developed an Online Asynchronous Discussion (OAD) framework that encourages students to apply contextual learning strategies to increase engagement and understanding of the material. Despite these advancements, there remains a lack of applied frameworks that integrate both quantitative and qualitative engagement indicators in small classroom contexts.

While many studies have evaluated the effectiveness of LMSs on a macro scale, research in micro-contexts, such as small classes or limited student groups, is still limited. Bakrania (2024) emphasizes that, although learning analytics in the micro-context has limited data, it allows for in-depth exploration of individual learning

behaviors. Furthermore, very few studies combine three data sources, LMS activity logs, pre- and post-test results, and in-depth interviews within a single exploratory framework. Integrating these data sources can offer a layered understanding of student learning, revealing how different forms of engagement interact and influence outcomes. However, integrating these three sources can provide a more comprehensive understanding of the dynamics of student engagement, particularly in concept-based courses like Applied Statistics.

This study aims to explore student engagement in LMS-based online learning in the Applied Statistics course using a data triangulation approach involving LMS activity logs, pre- and post-test results, and semi-structured interviews. By combining behavioral data, academic results, and student narratives, this study addresses the multidimensional nature of engagement and its relationship with academic success. The novelty of this research lies in the integration of these three types of data within a single exploratory framework applied to a microlearning context. The scope of the study focused on seventh-semester students in the Physics Education Study Program at Muhammadiyah University of Makassar taking the Applied Statistics course.

This context offers a unique setting to examine how digital learning tools are utilized in a relatively controlled learning environment, thereby reducing external variability and enhancing the clarity of observed engagement patterns. Although this study does not aim to generalize findings across larger populations, it offers valuable empirical insights. Student engagement encompasses three main dimensions: behavioral engagement (involvement in academic activities), emotional engagement (affective connection to learning), and cognitive engagement (deep and reflective learning strategies) (Fredricks et al., 2004; Reschly & Christenson, 2012). Emphasized that student engagement is the time and effort allocated to learning activities that are directly related to academic outcomes (Henrie et al., 2015; Kuh, 2009). In a digital context, using a learning analytics approach, suggests that learning activity logs can be used as evidence-based indicators to assess the learning process taking place in an LMS in real time and longitudinally (Ifenthaler & Yau, 2020; Siemens, 2013).

2. Methodology

This research was conducted on seventh-semester students of the Physics Education Study Program at Muhammadiyah University of Makassar taking the Applied Statistics course. The study was implemented during the odd semester of the 2023/2024 academic year using a blended learning model supported by an institutional LMS platform, SPADA Unismuh, which provides student activity log data. The primary research instruments included LMS log data (number of material accesses, forum participation, frequency of visits), pre-test and post-test scores as indicators of cognitive achievement, and a semi-structured interview guide to explore students' experiences during the online learning process. The pre-test and post-test instruments consisted of 10 multiple-choice items designed to assess conceptual understanding of statistical topics.

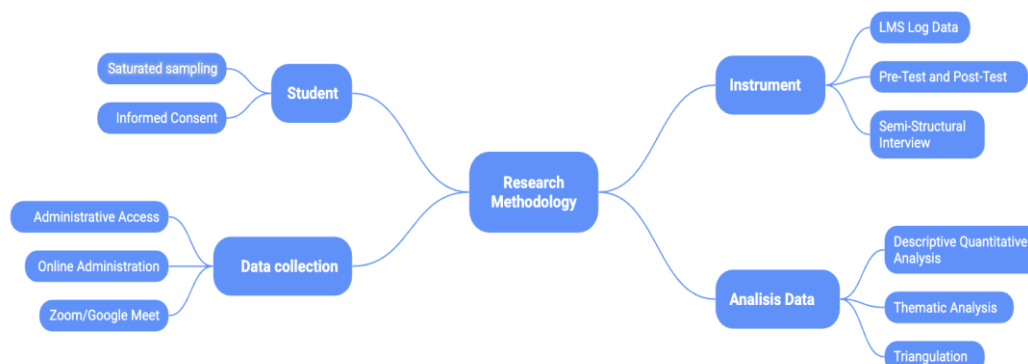


Figure 1. Research Methodology Framework for LMS Based Learning

This figure illustrates the overall research design used in the study, covering the four major methodological components: participants, data collection procedures, research instruments, and data analysis techniques. It summarizes how the LMS log data, test results, and semi-structured interviews were triangulated to understand behavioral, cognitive, and experiential aspects of student engagement. To complement the textual explanation, a visual map of the research methodology is provided in Figure 1. This map highlights the structured alignment between participants, data sources, and analytic procedures used in the study.

Subjects were selected using a saturated sampling technique, where the entire student population taking the Applied Statistics course in the current semester was used as respondents due to the limited number of students. The five students involved were all active participants in the class, so the data representation reflected the entire population. All participants were explained the purpose and procedures of the study and signed an informed consent form before data collection. LMS log data was collected through administrative access to the SPADA Unismuh system. Data collected included the number of accesses to learning materials, the frequency and duration of visits to the LMS, and the level of activity in discussion forums.

Each student's digital trace was anonymized using unique codes to ensure confidentiality. Formative tests, consisting of pre-tests and post-tests, were administered online before and after students accessed Learning Object Materials (LOM). Semi-structured interviews were conducted online via Zoom or Google Meet, recorded, and transcribed for further analysis. Interview questions explored themes such as learning strategies, technical challenges, perceived usefulness of the LMS, and emotional responses to digital learning. Each session lasted approximately 20–30 minutes and was conducted in the Indonesian language. Learning outcomes were calculated based on the difference between pre-test and post-test scores, converted into a percentage.

Quantitative parameters analyzed included the number of accesses to materials, frequency of interaction in forums, and pre-test and post-test scores. Qualitative parameters included perceived ease of use of the LMS, learning motivation, technical challenges encountered, and independent learning strategies. All

parameters were used to identify indicators of student engagement in LMS-based learning.

Data analysis was conducted using two approaches. First, descriptive quantitative analysis using SPSS software calculated the Pearson correlation between access frequency, discussion engagement, and learning outcomes. The results were presented in tables and bar charts. Second, interview transcripts were analyzed using thematic analysis to identify key themes related to student engagement (Braun and Clarke, 2006; Nowell et al., 2017). Coding was conducted manually by two independent reviewers to ensure inter-rater reliability. Data validation was carried out through triangulation between activity log data, test results, and interviews (Fetters et al., 2013).

3. Result and Discussion

Analysis of Student Activity Log in LMS

This study aims to explore student engagement in online learning using a Learning Management System (LMS) through analysis of activity logs, learning outcomes, and in-depth interviews. The results are presented in three main areas: (1) LMS activity logs, (2) improved learning outcomes, and (3) narratives of student experiences. Log data from the SPADA Unismuh Makassar LMS shows student activity in the form of access to materials and participation in online discussions. Table 1 summarizes the activity logs of five students:

Table 1. Student Activity in the LMS

No	Student	Access Material	Participation Discussion
1	Student 1	49	8
2	Student 2	49	8
3	Student 3	47	7
4	Student 4	51	8
5	Student 5	51	8

These data indicate that all students had a high level of access to the material and were actively involved in discussions. Discussion participation was consistent between 7–8 times, and material access ranged from 47–51 times. This reflects high student engagement with the Applied Statistics material delivered through the LMS. Such engagement levels suggest that students interacted frequently and meaningfully with course content, an indicator of active behavioral engagement.

Improved Learning Outcomes

To measure the impact of LMS activities on conceptual understanding, pre-test and post-test scores were measured. Table 2 shows the comparison of scores before and after learning using Learning Object Materials (LOM):

Table 2. Comparison of Learning Outcomes

No	Student	Pre-Test	Post-Test	Score Increase (%)
1	Student 1	53	80	50,84
2	Student 2	60	93	55,00
3	Student 3	53	75	41,51
4	Student 4	55	80	45,45
5	Student 5	63	95	50,79

These results indicate that all students experienced significant improvements in learning outcomes, with an average increase of over 48%. A positive correlation was also observed between the intensity of LMS activity and grade improvement, particularly among students with high levels of access and discussion. This reinforces the notion that sustained interaction with digital content contributes to improved cognitive achievement.

Correlation between LMS Activity and Learning Outcomes

Pearson correlation analysis showed a strong and significant relationship between the intensity of student activity in the LMS and improved learning outcomes (Field, 2018; Tabachnick & Fidell, 2013). The correlation between the number of material accesses and post-test score improvement was $r = 0.88$ ($p < 0.05$), while between participation in discussion forums and score improvement was $r = 0.85$ ($p < 0.05$). These findings support the study by Turnbull et al. (2021), which stated that active engagement in the LMS positively impacts learning outcomes. Compared with the study by Martin and Bolliger (2018), which emphasized the importance of interaction and social presence in the LMS, this study provides an additional contribution by demonstrating that quantitative aspects of engagement, such as frequency of access and number of discussion participations, are positively correlated with learning outcomes. Furthermore, this study supports the findings of Agustina and Cahyono (2017), who emphasized the role of the LMS as a cognitive aid in mastering statistical material. In the context of Applied Statistics courses, the use of interactive visual media in the LOM has been shown to help reduce students' cognitive load (Mayer et al., 2001; Reif et al., 2020; Sweller, 1988).

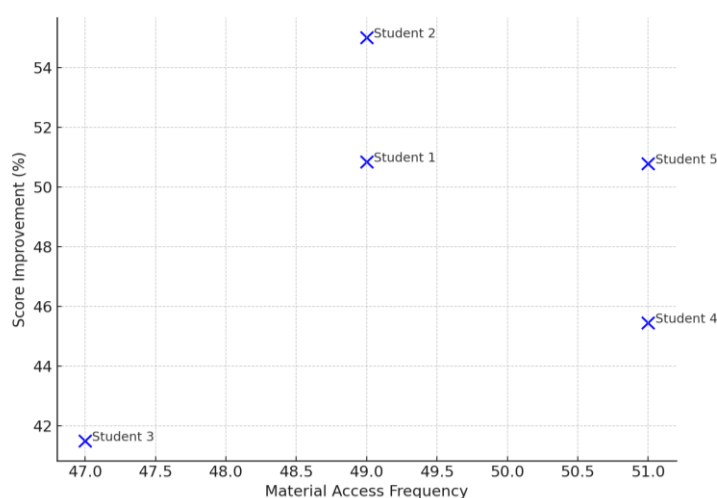


Figure 1. Relationship Between Material Access and Scores Improvement

Figure 1 shows a positive trend between the amount of material access and improvement in learning outcome scores. Although the sample size is limited, the graph shows that students with higher levels of access tend to experience greater improvement in their scores, supporting the results of the Pearson correlation test ($r = 0.88$; $p < 0.05$).

Qualitative Findings on Student Experiences

Semi-structured interviews revealed insights into students' perceptions and experiences with using the LMS and LOM:

- a. Student 1: "Usually, statistics are difficult to understand, but because there are animations and infographics, it's easier for me to visualize the data."
- b. Student 2: "The discussion forum really helps me. If I'm confused, I can ask questions, and sometimes my friends answer them directly." This finding supports previous studies that emphasized how online forums promote collaborative learning and conceptual elaboration (Garrison and Vaughan, 2008; Hrastinski, 2009).
- c. Student 3: "I prefer to study alone, but sometimes just reading isn't enough. After watching a video, I understand the formula better."

These findings indicate that the multimedia LOM in the LMS plays a significant role in bridging the understanding of abstract concepts, and the discussion feature contributes to increased collaboration and clarification of material.

Implications for Online Learning Design

The findings of this study underscore the dual role of LMS platforms not only as content delivery tools but also as environments that foster active learning when designed with engagement in mind. High student engagement, evidenced through LMS logs and forum activity, is a reliable predictor of academic success. For instructional designers and educators, this suggests the importance of embedding multimedia elements and designing structured forums that encourage student participation. Instructors should utilize LMS log data to monitor engagement trends and provide targeted feedback. Integrating such data into continuous evaluation supports personalized learning and aligns with evidence-based digital pedagogy (Boettcher & Conrad, 2016; Picciano, 2012). These implications are particularly relevant in small-class settings, where individual behavior is more visible, and interventions can be more precisely tailored.

Discussion

The results of the study indicate that students demonstrated a high level of intensity in accessing learning materials and actively participating in LMS discussion forums, both of which significantly impacted their learning outcomes. This finding is consistent with Fleck and Zhu (2024), who identified active participation in online discussions as a key predictor of academic success. In the context of Applied Statistics learning, the integration of multimedia-based Learning Object Materials (LOM) such as animations and infographics has been shown to facilitate the

comprehension of abstract statistical concepts, as echoed in student interview responses. These behavioral indicators of engagement align with the notion that frequent and meaningful interaction with learning resources is directly associated with enhanced academic performance. The relationship between LMS activity and learning gains is further validated by Pearson correlation tests, which revealed strong and statistically significant associations between both material access ($r = 0.88$) and discussion participation ($r = 0.85$) with post-test score improvements. These results reinforce previous findings by Zhang et al. (2024) and Althaqafi et al. (2025), who asserted that LMS log data can serve as a valid component in learning analytics frameworks to measure engagement and predict performance. This evidence contributes to the growing consensus that log data are not merely administrative artifacts but valuable pedagogical tools for real-time engagement assessment. Furthermore, this study supports the premise that LMS-based instructional designs that incorporate formative feedback mechanisms and monitor student activity in real time can effectively foster independent and reflective learning behaviors (Heikkinen et al., 2025).

From a qualitative perspective, students reported that the presence of animations, infographics, and structured discussion forums significantly facilitated their understanding of the material and enhanced their self-confidence during online learning. These multimedia elements helped students visualize abstract statistical concepts and relate them to real-world contexts, thus reducing cognitive overload and improving retention. Such tools support dual coding and multimedia learning principles, allowing learners to process information both verbally and visually, which is especially critical in complex, quantitative subjects like statistics. This finding aligns with Liu et al. (2025), who emphasized that student engagement in LMS environments enriched with interactive features and peer support leads to improved academic performance and emotional resilience. In particular, opportunities for peer explanation and collaborative problem-solving in forums were seen by students as key supports in bridging conceptual gaps. Furthermore, in the context of blended learning, sustained engagement especially when driven by continuous formative assessments has been shown to exert a stronger influence on final performance than summative evaluations alone (Graham, 2013; Yang et al., 2025). This suggests that engagement is not only a function of frequency but also of quality and intentionality, both of which were reflected in students' self-reported learning behaviors during interviews.

Overall, the results of this study confirm that a Learning Management System (LMS) functions not only as a medium for distributing instructional materials but also as a dynamic, analytical, and interactive platform that fosters the development of independent and reflective learning skills. Active student engagement when systematically tracked through LMS log data emerges as a key determinant of academic achievement in online learning environments. As emphasized by Kassim et al. (2025), the effectiveness of digital learning is closely tied to the design of systems that stimulate meaningful participation and facilitate real-time feedback mechanisms. This study extends that perspective by empirically demonstrating how a triangulated engagement model combining behavioral metrics, cognitive performance, and student reflection can serve as a comprehensive tool for

understanding and enhancing learner engagement. By bridging the gap between interaction data and learner experience, this model supports the development of more responsive instructional strategies. The practical implication of these findings is the urgent need to develop adaptive, interactive, and data-informed learning designs that actively engage students in both the content and learning process. Rather than relying solely on end-of-course assessments, instructors and institutions should integrate real-time engagement tracking into course management to support proactive instructional interventions. The use of LMS activity logs as an indicator of engagement offers a powerful opportunity for educators to implement early-warning systems, tailor feedback, and refine content delivery based on observed learning patterns. This approach also aligns with the broader shift toward precision education, where digital tools are used not just for delivery but for diagnosis and personalization of the learning experience.

4. Conclusion

This study confirms that the integration of a Learning Management System (LMS) into the Applied Statistics course significantly enhances both student engagement and academic outcomes. Engagement was evidenced by frequent and consistent access to course materials and active participation in discussion forums, indicating a high level of behavioral interaction with digital content. The strong and statistically significant correlation between LMS activity and post-test score improvement supports the claim that quantitative indicators such as material access frequency and forum participation can serve as valid proxies for academic success in online learning environments. Qualitative data enrich these findings by revealing how multimedia-based instructional materials, such as animations and infographics, as well as social learning structures like discussion forums, help students understand abstract statistical concepts and increase their self-efficacy.

This indicates that cognitive and emotional aspects of engagement are equally important and can be effectively nurtured through carefully designed digital environments. The core contribution of this study lies in the development of a triangulated engagement evaluation framework that integrates three distinct but complementary data sources: behavioral logs, cognitive performance, and student reflections. This model provides a holistic lens through which student engagement can be understood and improved. Unlike prior research that often relied solely on quantitative engagement metrics, this approach bridges the gap between numerical indicators and lived learning experiences, offering a richer, multidimensional understanding. Importantly, the study demonstrates that even in a microlearning context with a small sample size, meaningful patterns of engagement and learning gains can be identified and analyzed.

This highlights the potential of small-class learning analytics to inform targeted pedagogical strategies, making it highly relevant for institutions operating in similar settings. The findings underscore the need for content-driven, interactive, and adaptive instructional strategies that not only deliver knowledge but also foster autonomy, reflection, and emotional investment in learning. LMS log data, when

used proactively, can enable early identification of disengagement patterns, allowing instructors to implement timely and personalized interventions. Future research should explore the scalability and transferability of this evaluation model across different subject domains and educational levels. In particular, longitudinal studies are recommended to assess how sustained engagement impacts metacognitive development and long-term learning outcomes in digital environments.

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