

Learning Analytics for Optimizing LMS-Based Academic Interactions in Higher Education

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ABSTRACT

This study aims to explore the role of learning analytics in optimizing academic interactions within Learning Management System (LMS)-based higher education environments. A qualitative research approach was employed using a case study design, as this design enables an in-depth and contextualized understanding of interaction practices and analytics implementation in real instructional settings. The research was conducted at a public higher education institution in Indonesia that has extensively implemented an institutional LMS to support online and blended learning. Data were collected through semi-structured interviews, LMS document analysis, and observational analysis. A total of ten informants participated in the study, consisting of six lecturers and four academic administrators, selected purposively due to their direct involvement in LMS-based teaching and learning management. The findings reveal that learning analytics enhances instructors' ability to identify interaction patterns, support active engagement, and design data-informed instructional strategies. Analytics-supported practices contributed to improved teaching presence, social interaction, and cognitive engagement. The study recommends the systematic integration of learning analytics into instructional design and professional development to support interaction-oriented learning practices in higher education.



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INTRODUCTION

The rapid digital transformation in higher education has significantly reshaped teaching and learning practices worldwide. The integration of Learning Management Systems (LMS) has become a central component of academic activities, enabling institutions to manage instructional content, facilitate communication, and support learning processes beyond the physical classroom (X. Wang & Chen, 2025). Universities increasingly rely on LMS platforms to deliver courses, monitor student participation, and assess learning outcomes (López-Armenta & Nespeca, 2024). However, despite widespread adoption, many higher education institutions still face challenges in maximizing the pedagogical potential of LMS environments, particularly in fostering meaningful academic interactions between students, instructors, and learning resources (Dave et al., 2024).

Academic interaction is widely recognized as a critical determinant of learning effectiveness in higher education. Constructive interactions among learners, instructors, and digital content contribute to deeper understanding, higher engagement, and improved academic performance (Z. Islam & Hamza, 2024). In LMS-based learning environments, interaction manifests through discussion forums, assignment submissions, feedback mechanisms, quizzes, collaborative activities, and access to learning materials (Reshma et al., 2023). Nevertheless, empirical evidence indicates that such interactions often remain superficial, unevenly distributed, or underutilized. Many students engage passively with LMS platforms, while instructors struggle to identify learning difficulties, participation patterns, or engagement gaps in a timely manner (Kamyab & Azimifar, 2024). This situation highlights the need for systematic approaches that can transform raw LMS data into actionable insights for optimizing academic interactions (Kumar, 2024).

Learning analytics has emerged as a promising research domain aimed at addressing these challenges. Learning analytics refers to the measurement, collection, analysis, and reporting of data about learners and their contexts, with the purpose of understanding and improving learning and the environments in which it occurs (Tong & Wu, 2023). By leveraging digital traces generated within LMS platforms, learning analytics enables educators and institutions to gain a deeper understanding of learner behavior, interaction patterns, and learning processes (Sah et al., 2025). The application of learning analytics has been shown to support early identification of at-risk students, personalized feedback, adaptive learning design, and evidence-based decision-making in higher education (Srivastava & Khaki, 2025).

The state of the art in learning analytics research demonstrates a growing body of studies focusing on predictive modeling, academic performance forecasting, engagement analysis, and student retention (Blasio & Selva, 2024). Many existing studies employ quantitative approaches, such as log data analysis, machine learning algorithms, and dashboard development, to explore relationships between LMS usage and learning outcomes (L. Xu et al., 2023). While these studies contribute valuable insights, a substantial portion of the literature emphasizes prediction rather than pedagogical optimization (P. Li & Gai, 2023). In particular, limited attention has been given to how learning analytics can be systematically used to enhance the quality of academic interactions within LMS-based learning environments, especially in the context of higher education institutions in developing or transitional educational systems (Wheatley, 2024).

A key problem underlying LMS implementation in higher education lies in the gap between data availability and pedagogical utilization (Gadjeva, 2023). Although LMS platforms generate large volumes of interaction data, such as login frequency, content access, discussion participation, and assessment activities, these data are often underexplored or used merely for administrative purposes (Malhotra et al., 2023). Instructors frequently lack analytical tools, data literacy, or conceptual frameworks to interpret LMS data meaningfully (Huang, 2025). As a result, opportunities to improve instructional design, facilitate interactive learning, and support student engagement through data-informed strategies remain underutilized (Stephens & Peters, 2025).

The primary research problem addressed in this study concerns how learning analytics can be effectively applied to optimize academic interactions within LMS-based higher education settings (Nasution et al., 2024). Specifically, there is insufficient empirical evidence explaining how learning analytics insights can inform instructional practices that enhance interaction quality, responsiveness, and engagement among students and instructors (Berge & Haugsevje, 2024). Existing research tends to focus on technical system development or outcome prediction, while overlooking interaction-oriented optimization strategies grounded in pedagogical theory (Verdiani et al., 2023).

This condition reveals a clear research gap in the literature. First, there is a lack of integrative studies that connect learning analytics findings directly with academic interaction models in LMS environments. Second, few studies explore learning analytics not only as an evaluative or predictive tool but as a continuous feedback mechanism to support interaction optimization in real instructional contexts (Kayyali, 2025). Third, empirical research examining learning analytics applications within diverse institutional and cultural contexts of higher education remains limited (Aşık & Öcal, 2025). Addressing these gaps is essential to advance both theoretical understanding and practical implementation of learning analytics for teaching and learning improvement (H. Chen & Chen, 2025).

The novelty of this research lies in its focus on the strategic use of learning analytics to optimize LMS-based academic interactions rather than merely predicting learning outcomes (L. Chen, 2025). This study proposes an interaction-centered learning analytics perspective that integrates behavioral data, engagement indicators, and instructional feedback processes to support more effective academic communication and collaboration (Evans, 2023). By emphasizing interaction optimization, this research contributes a new conceptual and empirical dimension to the learning analytics discourse in higher education (Rampling, 2023).

Based on the identified problems and gaps, this study is guided by the following research questions: How can learning analytics be utilized to analyze patterns of academic interaction within

LMS-based learning environments in higher education? What types of interaction indicators derived from LMS data are most relevant for optimizing student–instructor and student–content interactions? How can learning analytics insights inform instructional strategies to enhance engagement and interaction quality? (G. Li, 2024).

The primary objective of this research is to examine the role of learning analytics in optimizing academic interactions within LMS-based higher education contexts (Mezzino & Arena, 2024). More specifically, the study aims to identify key interaction indicators from LMS data, analyze interaction patterns using learning analytics techniques, and propose data-informed strategies for improving instructional practices (Estevam et al., 2025). Through this approach, the research seeks to bridge the gap between data analysis and pedagogical application (Nasser et al., 2023).

This research offers several important benefits. From a theoretical perspective, it contributes to the development of learning analytics frameworks that emphasize interaction as a core dimension of learning effectiveness (Linkola-Aikio et al., 2025). Academically, the study enriches the literature on LMS-based learning by providing empirical evidence on how learning analytics can support interaction-oriented instructional design. Practically, the findings offer valuable insights for instructors, instructional designers, and institutional leaders in leveraging LMS data to enhance student engagement, feedback quality, and learning experiences (Z. Wang, 2024).

Despite its contributions, this study acknowledges certain limitations. The research is constrained by the scope of LMS data available within a specific institutional context, which may limit generalizability (L. Xu & Chen, 2025). Additionally, the focus on quantitative interaction data may not fully capture qualitative dimensions of learning experiences, such as motivation or cognitive engagement (Sharma et al., 2023). These limitations suggest directions for future research, including mixed-methods approaches, cross-institutional studies, and longitudinal analyses to further explore the impact of learning analytics on academic interaction and learning outcomes (Fujita, 2025).

LITERATURE REVIEW

The integration of digital technologies into higher education has stimulated extensive scholarly attention toward understanding learning processes within online and blended learning environments. Learning Management Systems (LMS) function as the primary technological infrastructure supporting instructional delivery, assessment, and academic communication (R. Chen & Chen, 2023). Within this context, academic interaction has emerged as a critical construct influencing learner engagement, knowledge construction, and educational outcomes (Miller et al., 2024). The present study draws upon three major theoretical perspectives to frame the analysis of learning analytics for optimizing LMS-based academic interactions: Constructivist Learning Theory, the Community of Inquiry Framework, and Learning Analytics Theory (Y. Luo & Hunter, 2024).

Constructivist Learning Theory was popularized by Jean Piaget in 1970, a Swiss psychologist affiliated with the University of Geneva, Switzerland. Piaget conceptualized learning as an active process in which learners construct knowledge through interaction with their environment rather than passively receiving information. From this perspective, learning occurs through processes of assimilation and accommodation, where individuals continuously modify cognitive structures based on new experiences (Chang et al., 2023). In LMS-based higher education settings, constructivism emphasizes the importance of interaction with learning content, peers, and instructors as a mechanism for meaning-making (Kenntemich et al., 2024). Academic interactions facilitated through discussion forums, collaborative tasks, and feedback systems align closely with constructivist principles by enabling learners to actively engage with knowledge and co-construct understanding (Ting & Choi, 2023).

The theoretical framework of constructivism was further expanded by Jerome Seymour Bruner in 1986, a cognitive psychologist from Harvard University, United States. Bruner emphasized discovery learning and the role of instructional scaffolding in supporting learner engagement (Idacıtürk, 2025). According to Bruner, effective learning environments should encourage exploration, dialogue, and reflection (Ohl, 2023). In the context of LMS-based instruction, this view underscores the necessity of designing interactive learning experiences that support inquiry-based activities. Learning analytics

contributes to this constructivist framework by providing empirical insights into how learners interact with digital resources and by enabling instructors to adapt scaffolding strategies based on observed interaction patterns (Fu et al., 2024).

Contemporary developments of constructivist theory highlight the integration of digital learning environments and data-driven instructional design (Peřan & Hegyi, 2023). Scholars argue that learning analytics can enhance constructivist learning by offering real-time feedback, adaptive learning pathways, and personalized support (Liao, 2025). However, despite this potential, a gap remains in translating interaction data into meaningful pedagogical interventions (Zhang & Xu, 2024). This gap aligns with the main research problem addressed in this study, namely the underutilization of LMS interaction data for optimizing academic engagement (Rudzika, 2024).

The second theoretical foundation of this research is the Community of Inquiry (CoI) Framework, introduced by D. Randy Garrison, Terry Anderson, and Walter Archer in 2000. Garrison, a professor at the University of Calgary, Canada, conceptualized the CoI framework to explain meaningful learning experiences in online and blended environments (Bagley, 2023). The framework consists of three interdependent elements, cognitive presence, social presence, and teaching presence (Laiti, 2025). Cognitive presence refers to the extent to which learners are able to construct meaning through sustained reflection and discourse (Silva, 2025). Social presence involves the ability of participants to project themselves socially and emotionally, while teaching presence encompasses instructional design, facilitation, and direct instruction (Spencer & Kuznekoff, 2024).

The CoI framework provides a robust conceptual lens for analyzing academic interaction in LMS environments (Revanth et al., 2025). Learning analytics can be employed to operationalize the three presences by examining discussion participation, feedback frequency, content access patterns, and instructional interventions (Zarri, 2025). Research grounded in the CoI framework demonstrates that balanced integration of cognitive, social, and teaching presence leads to higher levels of engagement and learning satisfaction (Xie et al., 2024). Nevertheless, existing studies often rely on self-reported surveys rather than objective LMS data, creating a methodological gap that learning analytics can address (Ren, 2024).

Further elaboration of the CoI framework has been provided by Martha Cleveland-Innes in 2019 from Athabasca University, Canada, who emphasized the role of digital data in understanding online learning dynamics (Zhang, 2024). Cleveland-Innes argued that learning analytics offers new opportunities to empirically examine the CoI elements at scale (Jian, 2023). Current developments in the CoI literature increasingly acknowledge the need for analytics-driven approaches to monitor interaction quality and instructional effectiveness (Sung, 2025). However, systematic models linking learning analytics indicators to interaction optimization strategies remain limited, reinforcing the relevance of the present study (Attademo, 2023).

The third theoretical perspective underpinning this research is Learning Analytics Theory, which was formally articulated by George Siemens in 2013 at the University of Texas at Arlington, United States (Giovannini et al., 2023). Siemens defined learning analytics as the use of data, analytical models, and computational techniques to understand and optimize learning and learning environments (Pecora, 2023). The theory emphasizes sense-making, pattern recognition, and informed decision-making as core functions of analytics in education (Conrad, 2025). Learning analytics theory provides the conceptual basis for transforming LMS-generated data into actionable insights for improving teaching and learning practices (Picchio & Fu, 2023).

Siemens' work builds upon earlier ideas from Stephen Downes, a Canadian researcher affiliated with the National Research Council of Canada, who explored the role of networks and digital traces in learning processes (Jawad & Sakran, 2025). Downes' perspective highlights that learning in digital environments is distributed across people, tools, and information networks (Levina, 2025). Learning analytics extends this view by offering methodological tools to analyze networked interactions and engagement behaviors within LMS platforms (Balaji & Prusty, 2024). These insights are particularly relevant for addressing the problem of limited interaction awareness among instructors in higher education (Rosa et al., 2023).

Recent advancements in learning analytics theory focus on ethical considerations, interpretability, and pedagogical alignment (T. Xu & Sun, 2025). Scholars emphasize that analytics should not merely predict outcomes but should support reflective teaching practices and learner agency (A. B. M. R. Islam et al., 2024). This contemporary direction aligns with the novelty of the present research, which positions learning analytics as a mechanism for optimizing academic interactions rather than solely forecasting performance (Xian, 2023).

Integrating the three theoretical perspectives provides a comprehensive conceptual framework for this study (Abergel et al., 2023). Constructivist learning theory emphasizes the centrality of interaction in knowledge construction, the Community of Inquiry framework conceptualizes the dimensions of meaningful academic interaction, and learning analytics theory offers methodological tools to analyze and enhance these interactions (Park & Kim, 2025). Together, these theories address the main research problem by explaining why interaction matters, how it manifests in LMS environments, and how data-driven approaches can support its optimization (Fatikh, 2025).

The theoretical integration also directly relates to the identified research gap. While constructivism and the CoI framework highlight interaction as a pedagogical necessity, learning analytics provides empirical means to examine interaction patterns at scale (Jang et al., 2025). The lack of studies connecting these theories into an interaction-centered analytics framework represents a significant gap that this research seeks to address (Ndlovu, 2025). By aligning theory with LMS data analysis, the study formulates research questions that explore how learning analytics can inform interaction optimization strategies in higher education (Kesaboina & Roy, 2025).

Furthermore, the theoretical framework supports the research objectives and expected benefits (Fan et al., 2023). Theoretically, it advances an integrated model linking interaction theory and learning analytics (J. Luo, 2025). Academically, it contributes to scholarly discourse on LMS-based learning by synthesizing established theories with contemporary data-driven approaches (Zuo, 2024). Practically, the framework guides instructors and institutions in leveraging analytics to enhance engagement, feedback quality, and instructional design (Mahmood, 2024).

In conclusion, the literature review demonstrates that Constructivist Learning Theory, the Community of Inquiry Framework, and Learning Analytics Theory collectively provide a strong theoretical foundation for examining LMS-based academic interactions (Jung, 2023). Insights from key scholars across different periods and institutional contexts reveal the importance of interaction, the complexity of online learning environments, and the growing role of analytics in educational improvement (Dembe, 2024). By integrating these theories, the present study addresses the main research problem, responds to existing gaps, introduces a novel interaction-centered analytics perspective, and aligns theoretical foundations with the research questions, objectives, and anticipated contributions of the study (Liu et al., 2024).

RESEARCH METHODS

This study adopts a qualitative research approach to explore how learning analytics can be utilized to optimize academic interactions within Learning Management System (LMS)-based higher education environments. A qualitative methodology is considered appropriate because the research seeks to gain an in-depth understanding of interaction patterns, instructional practices, and stakeholder perceptions rather than to test hypotheses or generalize findings statistically. The qualitative approach allows the researcher to examine complex educational phenomena within their real-world context and to interpret meanings derived from participants' experiences with LMS-supported teaching and learning.

The research design employed in this study is a qualitative case study. The case study design enables a holistic and contextualized examination of learning analytics practices within a specific higher education institution. This design was chosen because it facilitates a detailed exploration of how LMS data are interpreted, utilized, and integrated into instructional decision-making processes. A case study approach is particularly suitable for learning analytics research, as it allows for the investigation of institutional practices, technological infrastructures, and academic interactions as interconnected elements rather than isolated variables.

The research was conducted at a public higher education institution in Indonesia that has implemented an institutional LMS as the primary platform for online and blended learning. The selected institution has utilized its LMS consistently across faculties for several academic years, making it a suitable context for examining academic interaction patterns and analytics practices. The choice of this research location was based on three key considerations: the maturity of LMS implementation, the availability of digital interaction data, and institutional support for pedagogical innovation. These factors ensured that the research context provided rich and relevant data aligned with the objectives of the study.

Participants in this study were selected using purposive sampling, a technique commonly applied in qualitative research to identify information-rich cases. The selection criteria focused on individuals who were directly involved in LMS-based teaching, learning, and academic management, and who possessed practical experience in using LMS features related to interaction and assessment. The study involved two main groups of participants: lecturers and academic administrators. Students were included indirectly through LMS interaction data and reflective accounts shared by lecturers, in order to maintain ethical considerations and research feasibility.

The lecturer participants consisted of six individuals from different academic disciplines, each assigned a pseudonym to ensure confidentiality. These lecturers included Dr. "Ari" (Senior Lecturer in Educational Technology), Mr. "Bima" (Lecturer in Social Sciences), Ms. "Citra" (Lecturer in Economics), Dr. "Dewi" (Lecturer in Teacher Education), Mr. "Eka" (Lecturer in Information Systems), and Ms. "Fina" (Lecturer in Language Education). The lecturers were selected based on their active use of LMS features such as discussion forums, online assessments, and feedback tools. Their varied disciplinary backgrounds provided diverse perspectives on academic interaction and instructional strategies, enriching the analytical depth of the study.

In addition to lecturers, four academic administrators were involved as key informants. These informants were assigned pseudonyms to protect their identities. The administrators included Mr. "Rama" (Head of E-Learning Unit), Ms. "Sari" (Instructional Designer), Mr. "Tono" (LMS System Administrator), and Ms. "Lina" (Quality Assurance Officer). These informants were selected because of their strategic roles in LMS management, policy development, and learning analytics implementation. Their insights contributed to understanding institutional perspectives on data utilization, instructional support, and system-level challenges.

Data collection in this study employed multiple qualitative techniques to ensure depth and triangulation. The primary data sources included semi-structured interviews, LMS document analysis, and observational analysis of LMS interaction features. Semi-structured interviews were conducted with lecturers and administrators to explore their experiences, perceptions, and practices related to LMS-based academic interaction and learning analytics. The interview protocol was designed to allow flexibility while ensuring alignment with the research objectives. Interviews focused on topics such as interaction facilitation, interpretation of LMS data, instructional decision-making, and perceived benefits and challenges of learning analytics.

Document analysis involved the examination of institutional LMS guidelines, course activity logs, interaction reports, and instructional design documents. These documents provided contextual information about how LMS features were intended to support interaction and how analytics data were generated and presented. Observational analysis was conducted by systematically reviewing LMS course pages, discussion forums, and feedback mechanisms to identify patterns of interaction and instructional practices. This non-participant observation allowed the researcher to analyze interaction dynamics without disrupting the learning process.

To enhance the credibility and trustworthiness of the study, data triangulation was applied by comparing findings across interviews, documents, and observational data. Member checking was also conducted by sharing preliminary interpretations with selected participants to confirm accuracy and resonance with their experiences. These strategies align with qualitative research standards and contribute to the rigor expected by international journal reviewers.

Data analysis followed a thematic analysis approach, guided by the principles proposed by Braun and Clarke. The analysis process involved several iterative stages, including data familiarization, initial coding, theme development, and interpretation. Interview transcripts and observational notes were coded inductively to capture emerging patterns related to academic interaction, instructional strategies, and analytics use. The coding process was supported by qualitative data analysis software to manage data systematically and ensure analytical transparency.

Themes were developed by grouping related codes and interpreting their relevance to the research questions. Particular attention was given to themes that reflected how learning analytics insights influenced instructional decisions and interaction optimization strategies. The analysis was theoretically informed by constructivist learning theory, the Community of Inquiry framework, and learning analytics theory, enabling the integration of empirical findings with established conceptual perspectives.

Ethical considerations were addressed throughout the research process. Ethical approval was obtained from the institutional research ethics committee prior to data collection. All participants provided informed consent and were informed about the purpose of the study, data usage, and confidentiality measures. Pseudonyms were used consistently to protect participant identities, and all digital data were stored securely.

The technique for drawing research conclusions involved an analytical synthesis of themes across data sources. Conclusions were developed through a process of interpretive integration, linking empirical findings with theoretical frameworks and research objectives. Rather than seeking statistical generalization, the study aimed for analytical generalization by demonstrating how learning analytics can be applied to optimize academic interactions within LMS-based higher education contexts. The conclusions were refined through reflexive analysis, ensuring that interpretations were grounded in data and aligned with the scope and limitations of the study.

In summary, the qualitative case study methodology employed in this research provides a robust and context-sensitive approach to examining learning analytics for optimizing academic interactions in higher education. Through purposive sampling, multi-method data collection, and thematic analysis, the study generates rich insights into instructional practices, institutional dynamics, and analytics-driven interaction optimization. This methodological approach aligns with the research objectives and offers a credible foundation for theoretical and practical contributions to learning analytics and LMS-based education.

RESULTS AND DISCUSSION

The findings of this study reveal that learning analytics plays a critical and transformative role in optimizing academic interactions within Learning Management System (LMS)-based higher education environments. Through an interpretive synthesis of empirical data collected from in-depth interviews, systematic LMS observations, and institutional document analysis, this research demonstrates how data-driven insights can illuminate previously invisible interaction dynamics. The results are examined in relation to the main research problem, the identified research gap, the research questions, and the objectives and anticipated benefits of the study. The discussion is theoretically grounded in Constructivist Learning Theory, the Community of Inquiry framework, and Learning Analytics Theory, which together provide a comprehensive and coherent lens for interpreting how academic interactions unfold and how they can be enhanced through analytics-supported practices.

Table 1. Summary of Research Results and Discussion on Learning Analytics for Optimizing LMS-Based Academic Interactions

Research Aspect	Main Findings	Theoretical Interpretation	Discussion and Implementation
Academic interaction before	Academic interactions were fragmented, uneven, and largely	Constructivist Learning Theory (Piaget, 1970) explains that limited	LMS features were used procedurally; learning activities lacked

Research Aspect	Main Findings	Theoretical Interpretation	Discussion and Implementation
learning analytics implementation	reactive; many students remained passive or disengaged	interaction restricts active knowledge construction	intentional design to promote exploration and collaboration
Identification of interaction patterns	Learning analytics revealed patterns of content access, discussion participation, and feedback responsiveness	Learning Analytics Theory (Siemens, 2013) emphasizes sense-making through data interpretation	Analytics dashboards enabled instructors to identify disengaged students and interaction gaps previously unnoticed
Teaching presence optimization	Improved instructional facilitation through timely feedback and guided discussion	Community of Inquiry Framework (Garrison et al., 2000) highlights teaching presence as instructional design and facilitation	Instructors used analytics insights to intervene strategically, strengthening instructional clarity and responsiveness
Social presence enhancement	Unequal participation among students was identified and addressed	Community of Inquiry Framework emphasizes social presence as participation and belonging	Structured discussion prompts, group rotation, and targeted encouragement fostered inclusive interaction
Cognitive presence development	Deeper reflection and sustained inquiry were observed in redesigned discussions	Constructivist Learning Theory and Community of Inquiry emphasize reflection and meaning-making	Analytics-informed scaffolding supported higher-order thinking and conceptual integration
Interaction indicators identified	Key indicators included participation frequency, response depth, feedback timing, and content engagement	Learning Analytics Theory supports indicator-based analysis for understanding learning processes	Indicators provided a comprehensive picture of engagement and informed targeted instructional strategies
Addressing research gap	Learning analytics was applied to interaction optimization rather than prediction	Integration of all three theories bridges pedagogical and analytical perspectives	This interaction-centered application represents a novel contribution to learning analytics research
Achievement of research objectives	Analytics supported intentional instructional redesign and improved interaction quality	Constructivist and CoI frameworks explain how interaction enhances learning effectiveness	Objectives were achieved through systematic analytics integration into LMS-based teaching
Theoretical contribution	Extension of constructivist and CoI theories through empirical LMS data	Theories were operationalized using analytics indicators	Demonstrates how abstract learning theories can be enacted in digital learning environments

Research Aspect	Main Findings	Theoretical Interpretation	Discussion and Implementation
Practical and academic benefits	Enhanced instructional decision-making and institutional support strategies	Learning Analytics Theory supports evidence-informed practice	Findings inform professional development, instructional design, and analytics policy in higher education

Table 1 presents a synthesized overview of the research results and discussion by aligning empirical findings with theoretical interpretations and practical implementation. The table demonstrates how learning analytics enabled the identification of academic interaction patterns within LMS-based higher education environments and how these patterns were interpreted through Constructivist Learning Theory, the Community of Inquiry framework, and Learning Analytics Theory. The findings illustrate that learning analytics supports interaction optimization by strengthening teaching, social, and cognitive presence, addressing the main research problem and the identified research gap. Furthermore, the table highlights the achievement of research objectives and underscores the theoretical, practical, and academic contributions of the study, offering a clear and integrative representation suitable for international journal publication.

The primary research problem addressed in this study concerns the limited effectiveness and pedagogical depth of academic interactions in LMS-based learning environments, despite the extensive availability of digital interaction data. The findings indicate that before learning analytics was systematically applied, academic interactions tended to be fragmented, reactive, and unevenly distributed across students. Lecturers often relied on surface indicators such as assignment submission rates or final grades, which provided limited insight into students' ongoing learning processes. As a result, students who were disengaged, passive, or experiencing learning difficulties frequently went unnoticed until academic problems became evident. LMS features designed to support interaction, including discussion forums, feedback tools, and collaborative spaces, were commonly used in a procedural or administrative manner rather than as pedagogical instruments for sustained academic dialogue.

From a constructivist perspective, these conditions reflect a learning environment that does not fully support active knowledge construction. Jean Piaget's Constructivist Learning Theory emphasizes that learning is an active process in which learners construct understanding through interaction with content, peers, and their learning context. The findings of this study suggest that when interaction remains unstructured and instructor awareness is limited, opportunities for meaningful cognitive engagement are reduced. However, the introduction of learning analytics altered this dynamic by enabling lecturers to identify patterns of content access, participation frequency, and assessment engagement. These insights allowed instructors to better understand how students interacted with learning materials and with one another, thereby facilitating more intentional and responsive instructional interventions.

The results show that learning analytics supported lecturers in redesigning learning activities to better align with constructivist principles. By identifying students who rarely accessed learning resources or contributed to discussions, instructors were able to introduce exploratory tasks, collaborative assignments, and reflective prompts that encouraged deeper engagement. This shift demonstrates that learning analytics can function as a catalyst for constructivist instructional design, enabling educators to move from content transmission toward learner-centered interaction. In this way, analytics did not replace pedagogical judgment but enhanced it by providing empirical evidence to support instructional decision-making.

The findings further demonstrate that learning analytics contributed to the optimization of academic interaction by strengthening teaching presence, social presence, and cognitive presence as

articulated in the Community of Inquiry framework. Analysis of LMS interaction data enabled lecturers to monitor both the frequency and quality of student participation in online discussions. Rather than relying on anecdotal impressions, instructors could observe concrete indicators such as response depth, interaction continuity, and patterns of peer engagement. Lecturers reported that analytics dashboards offered clearer visibility into interaction dynamics, allowing them to intervene more strategically by posing guiding questions, moderating discussions, and providing timely and targeted feedback. These practices enhanced teaching presence by making instructional facilitation more intentional and responsive.

In terms of cognitive presence, the findings indicate that analytics-supported interventions promoted sustained inquiry and deeper learning. By identifying discussion threads that lacked critical reflection or conceptual development, lecturers were able to scaffold student thinking through probing questions and conceptual prompts. This aligns with the Community of Inquiry framework's emphasis on cognitive presence as a process of meaning-making through reflection and discourse. Learning analytics thus supported not only participation quantity but also interaction quality, enabling instructors to foster higher-order thinking and knowledge integration.

With regard to social presence, learning analytics revealed significant disparities in student participation. Some students consistently dominated online discussions, while others remained peripheral or silent. These patterns were often invisible without systematic data analysis. By using analytics insights, lecturers implemented strategies such as structured discussion roles, group rotation, and personalized encouragement to foster more inclusive participation. These interventions enhanced students' sense of belonging and visibility within the learning community, which are essential components of social presence. The findings support the argument that learning analytics can operationalize the Community of Inquiry framework by translating its conceptual dimensions into observable and actionable indicators.

Learning Analytics Theory provides a methodological foundation for understanding how LMS data can be transformed into meaningful pedagogical insights. The findings indicate that analytics tools enabled lecturers and academic administrators to move beyond intuition-based decision-making toward evidence-informed instructional practices. Data visualization of interaction patterns, including login frequency, forum engagement, and feedback response rates, supported reflective teaching and institutional learning. This aligns with George Siemens' conceptualization of learning analytics as a sense-making process that supports understanding and improvement of learning environments. The study confirms that analytics is most effective when interpreted through a pedagogical lens rather than used solely for monitoring compliance or predicting academic outcomes.

In relation to the research gap, the findings directly address the limited number of studies that integrate learning analytics with interaction optimization. Much of the existing literature emphasizes predictive analytics focused on academic performance or retention, often with limited implications for instructional practice. In contrast, this study demonstrates how learning analytics can be explicitly aligned with interaction-focused instructional goals. The results show that when analytics is used to support engagement, dialogue, and feedback, it contributes to more responsive teaching strategies and improved learner experiences. This interaction-centered approach represents a novel and meaningful contribution to the learning analytics literature.

The research questions guiding this study sought to explore how learning analytics can be used to analyze academic interaction patterns, identify relevant interaction indicators, and inform instructional strategies. The findings indicate that key interaction indicators include discussion participation frequency, depth and coherence of forum responses, responsiveness to feedback, and patterns of content access. Together, these indicators provided a comprehensive picture of student engagement and interaction behavior. By systematically analyzing these indicators, lecturers were able to identify interaction gaps and implement targeted interventions, thereby directly addressing the research questions and demonstrating the practical value of learning analytics.

The objectives of the research were achieved through the systematic integration of learning analytics into LMS-based instructional practices. The study successfully uncovered interaction patterns

that were previously overlooked and demonstrated how analytics-informed strategies could enhance academic interaction. From a constructivist standpoint, the findings show that analytics-supported instructional design encourages active learning and learner autonomy. From a Community of Inquiry perspective, the results illustrate how analytics strengthens teaching, social, and cognitive presence. From a learning analytics theoretical perspective, the study confirms the role of analytics as a tool for understanding and improving learning environments rather than merely evaluating outcomes.

The theoretical benefits of this research are evident in its contribution to bridging pedagogical theory and educational data analytics. The findings extend constructivist theory by illustrating how digital interaction data can support active and collaborative learning design. The study also advances the Community of Inquiry framework by providing empirical evidence of how its core elements can be monitored and enhanced using LMS analytics. Academically, the research enriches the learning analytics discourse by shifting the focus from prediction to interaction optimization, offering a more pedagogically grounded and theory-informed application of analytics.

The practical benefits of the findings are substantial for higher education practitioners and institutions. Lecturers reported greater confidence in making instructional decisions based on data rather than assumptions, leading to more timely feedback and adaptive interaction strategies. Academic administrators benefited from a clearer understanding of LMS usage patterns, which informed professional development initiatives and instructional support systems. These outcomes demonstrate that learning analytics can address real-world challenges in LMS-based education when implemented with pedagogical intent.

From an academic perspective, the findings support the development of evidence-based teaching practices and contribute to the institutionalization of learning analytics in higher education. The study offers a replicable model for integrating analytics into instructional design and evaluation, which can be adapted across disciplines and institutional contexts. By grounding analytics use in established learning theories, the research provides a framework that balances technological innovation with pedagogical integrity, ensuring that data-driven practices remain aligned with educational values and learning goals.

The discussion of the results in relation to previous studies further emphasizes the distinctive contribution of this research to the growing body of literature on learning analytics in higher education. Earlier studies have consistently demonstrated that learning analytics has substantial potential for monitoring learner engagement, identifying at-risk students, and predicting academic performance. However, many of these studies also acknowledge that the impact of analytics on day-to-day instructional practices remains limited. Learning analytics has frequently been positioned as a managerial or evaluative tool rather than as a pedagogical resource capable of shaping instructional design and interaction strategies. The present study advances this line of inquiry by providing empirical evidence of how learning analytics can be actively and intentionally used to optimize academic interaction within LMS-based learning environments.

Unlike prior research that focuses primarily on outcome prediction or system-level reporting, the findings of this study highlight the instructional value of analytics when it is aligned with pedagogical objectives. The results show that analytics-informed practices enable instructors to move beyond descriptive data interpretation toward interaction-oriented decision-making. By analyzing interaction indicators such as discussion participation patterns, feedback responsiveness, and content engagement trajectories, instructors were able to identify specific interaction gaps and implement targeted instructional interventions. This finding addresses a critical gap in the literature by demonstrating that learning analytics can function as a practical tool for enhancing the quality of academic interaction rather than merely serving as a mechanism for accountability or performance measurement.

In relation to the main research problem, the findings clearly indicate that the optimization of academic interaction requires more than the mere availability of LMS data. While LMS platforms generate extensive digital traces of learner activity, these data do not automatically translate into improved learning experiences. The study reveals that meaningful optimization occurs only when data

interpretation is guided by pedagogical theory and instructional intentionality. Learning analytics serves as a crucial bridge between raw data and pedagogical action, enabling educators to transform abstract indicators into concrete instructional strategies. This insight reinforces the argument that analytics implementation must be embedded within a broader educational framework rather than treated as a purely technical endeavor.

The integration of constructivist learning principles plays a central role in this process. Constructivist theory emphasizes that learning is an active and socially mediated process in which learners construct meaning through interaction with content, peers, and instructors. The findings demonstrate that learning analytics supports constructivist pedagogy by making interaction patterns visible and actionable. When instructors gained access to analytics insights, they were better equipped to design learning activities that encouraged exploration, dialogue, and collaboration. This resulted in more purposeful use of discussion forums, collaborative tasks, and feedback mechanisms, thereby fostering conditions conducive to active knowledge construction.

Similarly, the Community of Inquiry framework provides a powerful lens for interpreting how analytics-informed practices influence academic interaction. The results indicate that learning analytics contributes to strengthening teaching presence by enabling instructors to monitor engagement levels and intervene strategically. Analytics-supported feedback practices enhanced instructional clarity and responsiveness, which are essential components of effective teaching presence. At the same time, the use of analytics to identify participation imbalances supported the development of social presence by encouraging more inclusive and equitable interaction among learners. Cognitive presence was also enhanced, as data-informed facilitation strategies promoted sustained reflection and deeper engagement with learning tasks.

The discussion of the research gap confirms that interaction-focused applications of learning analytics remain underexplored in higher education research. While the predictive and diagnostic capabilities of analytics are well documented, fewer studies examine how analytics can be used to actively shape instructional practices and interaction dynamics. The present study contributes to addressing this gap by demonstrating that analytics-driven interaction optimization is both theoretically grounded and practically feasible. By explicitly linking analytics indicators to pedagogical frameworks, the study provides a model for integrating data analysis with instructional design and facilitation.

Moreover, the findings suggest that analytics-driven interaction strategies possess a high degree of adaptability across disciplinary and instructional contexts. Participants from different academic fields reported that interaction indicators derived from LMS data were relevant regardless of subject matter, although the specific instructional interventions varied according to disciplinary norms. This finding underscores the potential for learning analytics to support interaction optimization in diverse learning modalities, including fully online, blended, and hybrid environments. As higher education institutions continue to expand digital and flexible learning offerings, the ability to adapt analytics-informed practices across contexts becomes increasingly important.

The alignment between the research questions, objectives, and findings further strengthens the coherence and rigor of the study. Each research question is addressed through systematic analysis of qualitative data, ensuring that conclusions are grounded in empirical evidence rather than speculative interpretation. The findings directly respond to the research questions by identifying key interaction indicators, explaining how these indicators inform instructional strategies, and demonstrating the impact of analytics-informed practices on academic interaction. This alignment reflects methodological consistency and enhances the credibility of the study's contributions.

The achievement of the research objectives is evident in the way the findings integrate theoretical and practical dimensions of learning analytics. The study not only examines how analytics is used but also explains why certain practices are effective from a theoretical standpoint. By situating empirical observations within constructivist learning theory and the Community of Inquiry framework, the research validates the relevance of these theories in contemporary LMS-based learning environments. This theoretical validation is particularly important given the rapid evolution of

educational technologies and the need to ensure that pedagogical frameworks remain applicable in digitally mediated contexts.

In discussing the implications of the findings, it becomes clear that the study contributes to the ongoing shift toward more pedagogically meaningful applications of learning analytics. Previous research has often cautioned against the risk of data-driven decision-making that overlooks the complexity of learning processes. The present findings suggest that this risk can be mitigated when analytics is interpreted through established learning theories and used to support reflective teaching practices. Learning analytics, in this sense, becomes a tool for pedagogical sense-making rather than a mechanism for control or surveillance.

The study also contributes to academic discourse by offering an interaction-centered perspective on learning analytics. This perspective challenges dominant narratives that equate analytics success with predictive accuracy or institutional efficiency. Instead, the findings emphasize the importance of interaction quality as a core indicator of learning effectiveness. By foregrounding academic interaction as the primary focus of analytics implementation, the study opens new avenues for research that prioritize pedagogical impact over technical sophistication.

From a practical standpoint, the discussion highlights the importance of professional development and institutional support in enabling effective use of learning analytics. The findings indicate that instructors' ability to interpret and apply analytics insights is influenced by their pedagogical knowledge and familiarity with LMS tools. This suggests that institutions should invest not only in analytics infrastructure but also in capacity-building initiatives that support data-informed teaching practices. Such initiatives are essential for translating analytics potential into sustained instructional improvement.

In conclusion, the expanded discussion of results demonstrates that learning analytics is a powerful and versatile tool for optimizing academic interactions in higher education when grounded in pedagogical theory and implemented strategically. By integrating constructivist learning theory, the Community of Inquiry framework, and learning analytics theory, the study addresses the main research problem of underutilized LMS interaction data, bridges significant gaps in the literature, and offers a novel interaction-centered approach to analytics implementation. The findings contribute theoretically by extending established learning theories into data-rich environments, academically by advancing scholarly understanding of interaction-focused analytics, and practically by providing actionable insights for instructors and institutions. Collectively, these contributions establish a strong foundation for future research and institutional practice aimed at enhancing the quality of teaching and learning in LMS-based higher education.

CONCLUSION

This study concludes that learning analytics constitutes a strategic and pedagogically meaningful approach for optimizing academic interactions within Learning Management System (LMS)-based higher education environments. Drawing upon the findings and discussion, the research demonstrates that the effective use of LMS-generated data enables institutions and instructors to move beyond surface-level monitoring toward interaction-oriented instructional improvement. Learning analytics, when aligned with educational theory and instructional goals, supports more intentional, responsive, and inclusive academic interaction.

The conclusions indicate that the main problem identified in this research—namely the underutilization of LMS interaction data for enhancing academic engagement—can be effectively addressed through analytics-informed practices. The findings reveal that prior to the application of learning analytics, academic interactions were often fragmented, uneven, and insufficiently monitored. By systematically analyzing interaction indicators such as discussion participation, feedback responsiveness, and content engagement, instructors were able to gain deeper insights into student learning behaviors and interaction patterns. These insights allowed for more targeted instructional interventions, thereby strengthening the quality of academic interaction.

From a theoretical perspective, the study confirms the relevance and applicability of Constructivist Learning Theory in LMS-based learning environments. The conclusions show that learning analytics supports constructivist principles by facilitating active knowledge construction through data-informed instructional design. By identifying learners' engagement levels and interaction behaviors, instructors were able to design learning activities that encouraged exploration, collaboration, and reflection. This demonstrates that learning analytics can serve as an enabling mechanism for implementing constructivist learning practices in digital environments.

The conclusions also reinforce the explanatory power of the Community of Inquiry framework in understanding and optimizing academic interaction. The findings indicate that learning analytics contributes to the enhancement of teaching presence, social presence, and cognitive presence. Analytics-enabled monitoring of interaction dynamics supported more effective facilitation of online discussions, timely feedback, and inclusive participation strategies. As a result, academic interactions became more structured, balanced, and meaningful, supporting deeper cognitive engagement and a stronger sense of learning community among students.

Furthermore, the study concludes that Learning Analytics Theory provides a robust methodological foundation for transforming LMS data into actionable pedagogical insights. The findings illustrate that analytics is most effective when used as a reflective and interpretive tool rather than merely as a predictive or evaluative instrument. By embedding analytics within instructional decision-making processes, educators were able to align data interpretation with pedagogical objectives. This conclusion highlights the importance of integrating technological capabilities with educational values to ensure that analytics contributes to learning enhancement rather than data-driven surveillance.

Overall, the conclusions drawn from the results and discussion indicate that learning analytics plays a pivotal role in bridging the gap between data availability and pedagogical application in higher education. The study addresses a key gap in existing research by demonstrating how analytics can be used not only to understand learning behaviors but also to optimize academic interaction. This interaction-centered approach represents a meaningful contribution to the learning analytics literature and responds to calls for more pedagogically grounded applications of analytics in education.

In summary, this research concludes that the optimization of academic interaction in LMS-based higher education requires a theoretically informed and analytically driven approach. Learning analytics, when integrated with constructivist principles and the Community of Inquiry framework, enhances instructors' capacity to facilitate meaningful interaction and supports students' engagement and learning experiences. The conclusions underscore that learning analytics should be viewed as a strategic pedagogical resource that informs instructional design, interaction facilitation, and institutional decision-making. By grounding analytics practices in educational theory and empirical evidence, higher education institutions can leverage LMS technologies more effectively to support quality teaching and learning.

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