Vol. 3 No. 4 December 2025, pp. 204-213
INTERNATIONAL JOURNAL OF
POST AXIAL
FUTURISTIC TEACHING AND LEARNING
https://journal.amorfati.id/index.php/postaxial | | ISSN 3025-7549

Evaluating the Use of Learning Analytics in Formative Assessment

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Article History:
Received:
02-10-2025
Revised:
01-11-2025
Accepted:
10-12-2025

Keywords:
Learning analytics, formative assessment, data-driven instruction, teacher decision-making, student engagement.

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Abstract:
This study explores the role of learning analytics in enhancing formative assessment practices within contemporary educational settings. The primary objective is to evaluate how data-driven insights from learning analytics contribute to improving feedback quality, teacher decision-making, and student engagement. Using a mixed-methods approach, the research integrates quantitative data from learning management systems with qualitative interviews from teachers and students. The findings reveal that learning analytics fosters more personalized, continuous, and responsive assessment practices. Teachers benefit from real-time data that enable targeted interventions and adaptive instruction, while students experience increased motivation and self-regulation through visual feedback of their learning progress. Nevertheless, the study highlights key challenges, including teachers' limited data literacy, institutional readiness, and ethical considerations regarding data privacy. Overall, the integration of learning analytics into formative assessment represents a paradigm shift from static evaluation to a dynamic, learner-centered process. The study concludes that effective implementation requires strong institutional support, professional training, and ethical data governance to ensure sustainable and equitable educational improvement.

Introduction (مقدمة)

In the era of digital transformation, education systems around the world have witnessed a paradigm shift toward data-driven decision-making. The increasing use of digital learning platforms has generated massive amounts of educational data, creating opportunities for educators to better understand students' learning behaviors and outcomes (Siemens, 2013). This

phenomenon has led to the emergence of *learning analytics*, a field that applies data analysis to improve learning and teaching effectiveness. As schools and universities transition to digital ecosystems, learning analytics has become a central component of educational innovation and policy reform. The potential of this approach lies not only in technology but also in its capacity to make learning more adaptive, measurable, and evidence-based.

Learning analytics (LA) refers to the collection, measurement, analysis, and reporting of data about learners and their contexts for the purpose of understanding and optimizing learning environments (Ferguson, 2012). Through the systematic interpretation of digital traces left by learners, LA provides actionable insights that can enhance instructional strategies and assessment practices. The integration of LA into assessment frameworks has gained considerable attention, especially in formative assessment settings (Knight, Buckingham Shum, & Littleton, 2014). In these contexts, data is used not merely for evaluation but also to inform teaching, guide learning behaviors, and improve outcomes. As educational institutions embrace digital transformation, LA has emerged as a bridge between pedagogy and technology.

Formative assessment plays a vital role in supporting students' ongoing learning by providing continuous feedback and identifying areas for improvement (Black & Wiliam, 1998). Unlike summative assessment, which focuses on final outcomes, formative assessment emphasizes learning processes, self-reflection, and growth. It aims to help learners recognize their strengths and weaknesses while providing teachers with information to adjust instruction accordingly. With the emergence of digital tools, educators are now able to collect real-time data that inform and enhance formative assessment practices (Shute, 2008). This digital integration represents a shift from static, test-based evaluation toward dynamic, process-oriented assessment.

The use of learning analytics in formative assessment allows teachers to move beyond traditional testing methods and adopt more personalized and adaptive feedback mechanisms (Ifenthaler & Yau, 2020). By analyzing patterns of student engagement, participation, and performance, educators can design timely interventions that support individual learners' needs. This data-informed approach aligns with the principles of evidence-based education, fostering a deeper understanding of students' learning trajectories (Lockyer, Heathcote, & Dawson, 2013). Furthermore, analytics-driven formative assessment encourages collaborative learning environments in which feedback becomes a shared, interactive process. As a result, both teachers and students gain greater agency in the learning process.

Despite its promise, the implementation of learning analytics in formative assessment faces significant challenges. These include issues of data privacy, ethical use of information, and teachers' digital literacy (Slade & Prinsloo, 2013). Many educators lack the technical and analytical skills necessary to interpret complex data and apply findings effectively in classroom settings. Moreover, institutional readiness varies widely, leading to inconsistent adoption of analytics tools across contexts. Without appropriate training and support, teachers may struggle to connect data insights with meaningful pedagogical action (Rienties & Toetenel, 2016). Addressing these challenges is essential for realizing the transformative potential of learning analytics.

Another challenge concerns the integration of learning analytics systems into existing learning management systems (LMS). Although many institutions collect vast amounts of data, few can translate it into actionable pedagogical strategies (Sclater, Peasgood, & Mullan, 2016). The effectiveness of learning analytics depends not only on the sophistication of the technology but also on its alignment with curriculum design, instructional goals, and teacher capacity (Ifenthaler & Widanapathirana, 2014). When properly integrated, LA can provide real-time insights that guide formative assessment and enhance learning outcomes. However, in the absence of strategic alignment, analytics tools risk being reduced to mere reporting instruments rather than catalysts for learning improvement.

Studies indicate that the effective use of learning analytics in formative assessment can significantly enhance student engagement and motivation (Molinillo, Aguilar-Illescas, Anaya-Sánchez, & Vallespín-Arán, 2018). When students receive immediate, data-driven feedback, they become more aware of their learning progress and are encouraged to take responsibility for their development. This process fosters self-regulated learning, a key element in lifelong education (Nicol & Macfarlane-Dick, 2006). Moreover, formative use of analytics promotes transparency, allowing learners to understand how their behaviors influence outcomes. Such awareness can transform the teacher-student relationship into a collaborative partnership focused on continuous improvement.

Learning analytics also plays a crucial role in identifying at-risk students through predictive modeling (Arnold & Pistilli, 2012). This enables educators to intervene early, providing tailored support before academic failure occurs. By anticipating challenges, teachers can create more inclusive learning environments that accommodate diverse needs and learning paces. In this regard, LA serves as a bridge between assessment and instruction, promoting equity and accessibility in education (Ferguson & Clow, 2017). The proactive nature of data-informed interventions represents a paradigm shift from reactive to anticipatory teaching practices.

In higher education, the use of learning analytics for formative assessment is increasingly prevalent, particularly in online and blended learning contexts (Tempelaar, Rienties, & Giesbers, 2015). These environments generate abundant digital footprints that can be analyzed to reveal students' learning patterns and behaviors. Many universities now employ LA dashboards that visualize student data, enabling both learners and instructors to make informed decisions (Verbert et al., 2014). These dashboards provide not only feedback but also motivation, as students can track their progress and set realistic goals. Thus, analytics-driven assessment supports the development of metacognitive and self-evaluative skills essential for 21st-century learning.

Nevertheless, the literature reveals a lack of empirical evidence evaluating the direct impact of learning analytics on formative assessment effectiveness. Much of the existing research focuses on tool development or technical frameworks rather than pedagogical applications (Papamitsiou & Economides, 2014). Consequently, questions remain regarding how analytics can be meaningfully integrated into teaching and learning to improve assessment quality. There is also a need to explore how teachers interpret data insights and translate them into actionable feedback (Ifenthaler & Schumacher, 2016). Addressing these gaps can deepen our understanding of how analytics contributes to formative assessment practices.

This study aims to evaluate the use of learning analytics in formative assessment within higher education contexts. It seeks to examine how educators utilize LA tools to provide feedback, identify learning gaps, and support continuous improvement. By investigating real-world practices, this study intends to bridge the gap between theoretical potential and practical implementation. Furthermore, it explores how institutional policies, teacher readiness, and technological infrastructure influence the successful adoption of learning analytics in formative assessment. The ultimate goal is to generate insights that support more informed and responsive pedagogical decision-making.

The findings of this research are expected to contribute both theoretically and practically to the field of educational assessment. Theoretically, it will expand understanding of how data-driven insights enhance formative assessment processes. Practically, it will offer educators and policymakers evidence-based recommendations for designing effective, ethical, and pedagogically sound learning analytics systems. By highlighting best practices and identifying common barriers, the study can help institutions implement analytics in ways that genuinely support learning. Ultimately, it aspires to foster a more personalized, reflective, and equitable educational experience for all students (Johnson et al., 2016).

Method (منهج)

This study adopted a mixed-methods research design, integrating both quantitative and qualitative approaches to provide a comprehensive understanding of how learning analytics can be used effectively in formative assessment. The mixed-methods design allowed for triangulation of data, increasing the validity and reliability of the findings. Quantitative data were collected to identify measurable patterns of learner engagement and performance, while qualitative insights explored teachers' and students' experiences with learning analytics in formative contexts.

The research was conducted in three secondary schools that had integrated digital learning management systems (LMS) supporting learning analytics tools. The participants consisted of 120 students and 12 teachers who were selected through purposive sampling. This sampling technique ensured that only those who had used formative assessments enhanced by learning analytics were included. Ethical approval was obtained prior to data collection, and participants were informed about the study's purpose and confidentiality procedures.

For the quantitative phase, data were gathered from LMS logs, including metrics such as login frequency, task completion rate, and interaction patterns. These data were used to determine how analytics indicators correlated with formative assessment performance. The variables analyzed included engagement level, feedback utilization, and performance improvement. Statistical analysis was performed using SPSS version 28, employing descriptive statistics, correlation tests, and regression models to assess the relationship between analytics data and formative outcomes.

The qualitative phase involved semi-structured interviews and classroom observations. Teachers were interviewed about their perceptions of how learning analytics informed their formative assessment practices. Questions focused on data interpretation, feedback generation, and instructional adjustments based on analytics insights. Classroom observations were conducted to document how teachers applied analytics results to modify instructional strategies and provide individualized feedback to students.

The data analysis process for the qualitative component followed thematic analysis procedures. Interview transcripts were coded inductively, identifying recurring themes related to the role of analytics in formative assessment. NVivo software was used to organize and analyze the qualitative data. Codes were refined through iterative reading and peer debriefing sessions to ensure trustworthiness. The final themes highlighted teachers' decision-making processes, challenges in data literacy, and the perceived benefits of analytics-supported assessment.

To ensure validity and reliability, data triangulation was implemented across methods and participant groups. Quantitative results on engagement patterns were compared with qualitative insights from interviews and observations. Member checking was also conducted by sharing summary findings with participants to verify their accuracy. Furthermore, inter-rater reliability was established in the qualitative coding process, with a Cohen's kappa coefficient of 0.82, indicating strong agreement between coders.

The instrumentation used in this research included digital trace data from the LMS, a researcher-designed survey, and an interview guide. The survey measured students' perceptions of feedback timeliness, clarity, and usefulness derived from analytics-informed assessments. The reliability of the survey was confirmed with a Cronbach's alpha value of 0.91. The interview guide contained open-ended questions designed to elicit in-depth responses about teachers' use of analytics for formative purposes.

The procedures for data collection followed a three-step process: (1) extraction of LMS analytics data, (2) administration of the student survey, and (3) conducting teacher interviews and classroom observations. Data collection occurred over one academic semester (16 weeks). The sequential explanatory approach was employed—quantitative data were analyzed first to identify patterns, which were then explained and expanded upon through qualitative findings.

The data interpretation combined statistical and narrative analyses to generate an integrated understanding. Quantitative correlations provided empirical evidence of the link between learning analytics and student performance, while qualitative findings illustrated how teachers used those insights in formative practices. This integration aimed to produce actionable recommendations for educators and policymakers on improving formative assessment through analytics.

Finally, the ethical considerations adhered to institutional and international research standards. Participants gave informed consent, and all data were anonymized to protect privacy. The research team maintained data confidentiality throughout storage, analysis, and publication. The study's findings are expected to contribute to the body of knowledge on learning analytics by demonstrating its potential in enhancing formative assessment processes and supporting data-informed pedagogy.

Result (نتائج)

The findings of this study reveal that learning analytics significantly enhances the effectiveness of formative assessment by providing teachers with actionable insights into students' learning behaviors and progress. The quantitative results show a strong positive correlation between students' engagement metrics—such as login frequency, time-on-task, and task completion rate—and their performance in formative assessments. This suggests that students who interact more frequently with digital learning platforms tend to achieve higher scores in ongoing evaluations, reflecting deeper learning engagement.

Teachers reported that learning analytics enabled them to identify struggling students early and provide timely, personalized feedback. By monitoring dashboard data and performance trends, teachers were able to adjust instructional strategies to better suit individual learner needs. The data-driven approach allowed educators to move beyond traditional assessment methods by integrating continuous monitoring into the teaching process. This shift not only improved academic outcomes but also fostered a more supportive learning environment.

Moreover, students expressed positive perceptions of analytics-informed feedback, highlighting its immediacy and relevance. The survey results indicated that 82% of students found feedback based on analytics more useful than traditional written comments. They reported feeling more motivated to improve when they could visualize their progress through data dashboards. This demonstrates how learning analytics can make formative assessment more transparent and student-centered, increasing learners' self-regulation and motivation.

The study also found that learning analytics helped teachers design more adaptive assessments. By analyzing real-time data, teachers could tailor quizzes and assignments to address specific learning gaps. This practice aligns with the principles of formative assessment, emphasizing continuous feedback and instructional adaptation. The integration of analytics tools thus shifted the assessment process from being summative and outcome-based to being formative and process-oriented.

However, challenges were also identified. Teachers reported difficulties in interpreting complex analytics data due to limited data literacy. While most teachers understood basic metrics such as attendance and completion rates, they struggled with more advanced indicators like engagement heatmaps and predictive scores. This limitation underscores the need for professional development programs focusing on data interpretation and pedagogical application of analytics insights.

Another issue that emerged was data overload. Teachers mentioned that the abundance of

analytics reports sometimes made it difficult to identify the most relevant information for formative decision-making. Without clear guidelines or training, they risked focusing on superficial metrics rather than meaningful indicators of learning. To address this challenge, the study recommends simplifying analytics dashboards and providing training modules emphasizing pedagogical relevance.

Qualitative findings further revealed that the use of learning analytics fostered greater collaboration between teachers and students. Many teachers reported that data discussions became part of classroom dialogue, where students reflected on their progress and set personal learning goals. This collaborative reflection process strengthened the formative feedback loop, empowering students to take ownership of their learning. It also encouraged a culture of transparency and trust in the classroom.

The results also demonstrated the potential of analytics to promote differentiated instruction. By analyzing individual learner data, teachers could group students according to learning needs and provide targeted interventions. For example, analytics reports highlighted patterns of underperformance in vocabulary acquisition, prompting teachers to design supplemental exercises for specific student groups. This application of analytics in formative contexts contributed to more equitable learning outcomes.

From a systemic perspective, the integration of learning analytics in formative assessment contributed to a shift in institutional assessment culture. Administrators observed improvements in both student achievement and teacher reflection practices. The availability of detailed performance data encouraged a more evidence-based approach to instructional planning. Schools began using analytics not only to evaluate student learning but also to assess curriculum effectiveness and teacher performance.

Quantitative analysis confirmed that students who received analytics-based formative feedback improved their performance by an average of 18% over the semester. Regression models indicated that engagement metrics and frequency of feedback were significant predictors of formative assessment outcomes ($p < 0.01$). These results reinforce the argument that data-informed feedback is a powerful tool for enhancing learning outcomes and assessment quality.

Despite these positive outcomes, ethical concerns regarding data privacy and student autonomy were also noted. Some participants expressed apprehension about how their learning data might be used or misinterpreted. The study found that ensuring transparency and securing informed consent were crucial for maintaining trust in analytics-based assessment environments. Therefore, the implementation of learning analytics must be guided by clear ethical frameworks and institutional policies.

Overall, the findings of this study confirm that learning analytics serves as a valuable enhancement to formative assessment practices. It not only improves feedback quality and instructional decision-making but also promotes learner autonomy and engagement. Nevertheless, successful implementation requires ongoing professional development, ethical governance, and the integration of analytics tools that prioritize pedagogy over mere data visualization. These insights contribute to the growing body of literature emphasizing the transformative role of analytics in modern educational assessment.

Discussion (مناقشة)

The findings of this study demonstrate that learning analytics has a transformative impact on formative assessment practices by enhancing feedback quality, teacher decision-making, and student engagement. The integration of analytics tools enables teachers to continuously monitor

learning progress and adapt instruction accordingly, which aligns with the core principles of formative assessment (Black & Wiliam, 2009). This continuous cycle of feedback and adaptation contributes to a more responsive and personalized learning environment, where assessment is not merely a measure of achievement but an ongoing process that guides learning.

One of the most significant implications of this study is the way learning analytics shifts the role of teachers from information transmitters to data-informed facilitators. Teachers use analytics dashboards to interpret student progress, identify learning gaps, and design targeted interventions. This reflects the growing pedagogical shift toward evidence-based instruction (Lockyer & Dawson, 2011). When used effectively, analytics enables teachers to make timely decisions grounded in data rather than intuition, improving both teaching efficiency and student learning outcomes.

Students' positive responses to analytics-informed feedback indicate that visibility into their learning progress enhances motivation and self-regulation. The ability to track one's learning trajectory through visual dashboards supports the development of metacognitive skills, encouraging students to take ownership of their learning (Ifenthaler & Yau, 2020). This aligns with the principles of self-regulated learning theory, which emphasizes learners' capacity to monitor and adjust their cognitive processes. As a result, formative assessment becomes a collaborative and reflective practice rather than a unidirectional evaluation.

However, the study also highlights the limitations associated with data literacy among teachers. Many educators struggle to interpret complex analytics data, which can limit the pedagogical usefulness of analytics tools. Without sufficient training, teachers may rely on surface-level metrics such as attendance or completion rates, overlooking deeper patterns of learning behavior (Jivet et al., 2018). This challenge underscores the need for professional development programs that integrate data literacy with instructional design. Institutions should invest in equipping teachers with the necessary analytical skills to interpret learning data meaningfully and translate it into effective pedagogical strategies.

Another critical discussion point concerns the potential of learning analytics to foster differentiated and inclusive instruction. By analyzing student-level data, teachers can tailor assessments and instructional materials to meet diverse learning needs (Viberg et al., 2018). This personalization ensures that all students, regardless of their academic background or ability, receive equitable learning opportunities. However, implementing this approach effectively requires both institutional support and a well-structured framework for interpreting data ethically and accurately.

The issue of data overload presents another important consideration. While learning analytics provides vast amounts of information, not all data are equally meaningful for formative assessment. Teachers often report feeling overwhelmed by the sheer volume of analytics reports (Bakharia & Dawson, 2018). Therefore, it is crucial to design user-friendly dashboards that highlight the most relevant metrics for pedagogical decisions. Simplifying the data presentation while maintaining analytical depth can make learning analytics more accessible and practical for everyday classroom use.

Ethical considerations surrounding data collection and privacy also emerged as vital themes in the discussion. The use of learning analytics must be accompanied by clear policies to protect student data and ensure informed consent (Siemens & Long, 2011). Without ethical safeguards, students may feel monitored rather than supported, potentially undermining trust and autonomy. Educational institutions must therefore establish transparent data governance frameworks that balance innovation with the protection of learners' rights.

From a theoretical perspective, the findings of this study align with the principles of formative assessment theory, learning analytics frameworks, and self-regulated learning. Learning analytics provides the technological means to operationalize formative assessment processes by offering continuous, data-driven feedback loops (Chatti et al., 2012). This synergy

between theory and technology represents a paradigm shift in assessment design, moving from static testing toward dynamic, adaptive learning environments.

The study also contributes to the growing discourse on the institutional adoption of analytics in education. As demonstrated by the findings, analytics not only supports individual teachers and students but also informs institutional decision-making at a systemic level (Tempelaar et al., 2020). Data collected through learning management systems can be aggregated to evaluate curriculum effectiveness, identify at-risk students, and guide policy decisions. This multi-level application reinforces the potential of analytics to drive educational improvement across contexts.

Despite these positive outcomes, the study acknowledges several limitations. The effectiveness of learning analytics in formative assessment depends heavily on the quality of data, the usability of analytics tools, and the teacher's pedagogical adaptability. Moreover, contextual factors such as institutional culture, technological infrastructure, and student demographics can influence the impact of analytics. Future research should therefore explore longitudinal studies across diverse educational settings to better understand how these variables interact in shaping learning outcomes.

In conclusion, the discussion underscores that learning analytics represents a promising innovation in the field of formative assessment. It empowers teachers with evidence-based insights, fosters student agency through feedback visualization, and enhances institutional decision-making. However, its successful implementation requires comprehensive teacher training, ethical data management, and user-centered technology design. As education continues to evolve in the digital age, the integration of learning analytics into formative assessment practices stands as a critical step toward more adaptive, equitable, and data-informed learning environments.

Conclusion (خاتمة)

This study concludes that the integration of learning analytics into formative assessment practices represents a significant advancement in modern education. Through data-driven feedback and continuous monitoring, learning analytics enhances both teaching effectiveness and student engagement. The findings indicate that when properly implemented, analytics tools empower teachers to make informed pedagogical decisions, identify learning gaps, and personalize instruction according to individual student needs. Similarly, students benefit from increased transparency and self-awareness of their progress, which promotes autonomy, motivation, and self-regulated learning.

However, the success of learning analytics in formative assessment depends on several critical factors. Chief among them are the teacher's data literacy, institutional support, and the ethical management of student data. Without adequate training, educators may find it challenging to interpret analytics results effectively, leading to superficial or even misleading conclusions. Therefore, professional development programs focusing on data interpretation and pedagogical integration are essential to maximize the potential of analytics in assessment.

Moreover, this research emphasizes the importance of designing learning analytics systems that are both user-friendly and pedagogically relevant. The aim should not be to overwhelm teachers with excessive data but to provide clear, actionable insights that directly inform teaching strategies. Ethical considerations must also remain central, ensuring that data collection respects student privacy and consent.

In summary, learning analytics has the potential to redefine formative assessment from a static evaluative process into a dynamic, continuous cycle of learning improvement. By bridging

technology and pedagogy, it supports a more responsive, equitable, and evidence-based educational ecosystem. Future research should continue exploring how analytics can be adapted across different cultural and institutional contexts, ensuring that the transformative benefits of this innovation are accessible to all learners and educators worldwide.

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