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Leveraging learning analytics to enhance curriculum effectiveness in digital classrooms

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Abstract
As digital classrooms become integral to modern education, learning analytics (LA) emerges as a strategic enabler to refine curriculum delivery and enhance student outcomes. This paper explores how learning analytics can be used to boost curriculum effectiveness in digital environments. A mixed-methods study was conducted with 300 students and 25 instructors from Bangladeshi universities using Moodle and Google Classroom. Findings reveal that real-time analytics enable adaptive teaching, optimized content design, and early intervention for at-risk learners. Visual analysis supports that engagement levels, content formats, and early participation significantly influence academic performance and dropout risk. Policy recommendations include faculty training, ethical data frameworks, and national LMS standardization. The study concludes that LA is not merely a monitoring mechanism but a transformative tool for personalized, inclusive, and effective education.

Keywords: Digital classrooms, personalized, inclusive, enhance curriculum effectiveness

Introduction
The landscape of education has been transformed dramatically by the proliferation of digital technologies and the rapid expansion of online learning platforms. Over the past decade, the traditional brick-and-mortar classroom has increasingly been supplemented or even replaced by digital classrooms, driven by the rise of Learning Management Systems (LMS), online content repositories, and real-time assessment tools. The shift towards digital education has not only altered the delivery of instructional content but has also opened new avenues for understanding and optimizing the learning process itself. One of the most promising developments in this domain is the emergence of Learning Analytics (LA) a data-driven approach that leverages digital traces left by learners in virtual environments to enhance teaching, learning, and curriculum development.

Learning analytics refers to the collection, measurement, analysis, and reporting of data about learners and their contexts, for the purpose of understanding and optimizing learning and the environments in which it occurs. At its core, LA seeks to transform raw data into meaningful insights that can inform instructional strategies, personalize content delivery, and support student retention. The origin of LA is rooted in data science, but its application in education has grown exponentially, particularly with the increasing reliance on platforms such as Moodle, Google Classroom, Blackboard, Canvas, and various Massive Open Online Course (MOOC) platforms. These systems generate large volumes of learner data-ranging from login frequency and time-on-task to quiz performance and discussion forum participation which, if analyzed effectively, can reveal patterns of engagement, performance, and risk.

As institutions navigate the complex demands of Education 4.0, which emphasizes student-centered learning, flexibility, and technological integration, LA has emerged as a vital component in driving evidence-based pedagogical transformation. However, the integration of LA into curriculum design is still at a nascent stage, especially in developing countries like Bangladesh, where digital infrastructure and data literacy are unevenly distributed. Despite significant strides in digitizing education such as the introduction of national LMS platforms and remote teaching initiatives during the COVID-19 pandemic many institutions still lack the systemic capacity to utilize LA in a meaningful way. Faculty members often face challenges in interpreting analytics dashboards, and institutional policies regarding data ethics and student privacy are frequently underdeveloped.

In Bangladesh, the potential of LA to enhance curriculum effectiveness remains underexplored in both academic literature and policy discourse. Most institutions rely on LMS systems primarily for content dissemination and basic assessments, rather than as tools for diagnostic feedback, predictive intervention, or curriculum restructuring. This oversight limits the opportunity to transform static content delivery into a dynamic, responsive learning experience. Yet, several trends underscore the urgent need to adopt LA more comprehensively. First, dropout rates in online and hybrid courses remain high, particularly among students with limited access to consistent digital connectivity or personalized support. Second, the one-size-fits-all approach to digital instruction often fails to engage diverse learners with varying academic backgrounds and learning preferences. Third, as the volume of educational data grows, the failure to analyze and act upon it represents a missed opportunity to bridge achievement gaps and foster inclusive learning environments.

The integration of LA into digital classrooms can significantly enhance curriculum effectiveness by enabling a shift from intuition-based teaching to evidence-informed practice. Through LA, educators can track which content formats resonate most with students, identify disengaged learners in real time, and tailor interventions to individual needs. For example, a dashboard that highlights students who have not logged in during the first two weeks of a course can prompt early outreach, potentially reducing dropout rates. Similarly, analytics that reveal low interaction with text-heavy modules might inspire curriculum designers to incorporate more multimedia or interactive components. When used strategically, LA not only enhances instructional design but also fosters student agency by providing learners with insights into their own progress and performance.

This paper seeks to explore the transformative potential of learning analytics in improving curriculum delivery and learner outcomes in digital classrooms, with a particular focus on the higher education sector in Bangladesh. By combining quantitative metrics from LMS platforms with qualitative insights from students and instructors, this study aims to (i) assess how different aspects of LA such as engagement tracking, performance analytics, and content interaction-impact academic outcomes, and (ii) provide policy and pedagogical recommendations for embedding LA into curriculum planning. The study addresses a critical gap by contextualizing global LA practices within the specific infrastructural, cultural, and educational realities of Bangladesh.

Moreover, the significance of this research lies in its bottom-up approach-emphasizing grassroots insights from both learners and faculty, rather than top-down technological impositions. The findings are expected to inform institutional strategies on faculty development, ethical data use, and the standardization of LMS platforms, thus supporting a more coherent and scalable adoption of LA. The study also aligns with broader educational goals, such as the Sustainable Development Goal 4 (Quality Education), by advocating for equitable access to personalized and adaptive learning pathways.

Literature Review

The field of Learning Analytics (LA) has evolved considerably over the past decade, gaining momentum as digital education platforms became mainstream in higher education. Its conceptual foundation lies in the intersection of educational theory, data science, and instructional design, with the core objective of extracting actionable insights from learner data to inform teaching and learning decisions. According to Siemens and Long (2011) [1], LA represents a pivotal shift from traditional, intuition-based pedagogy to data-informed educational practices. They argue that LA allows educators to "penetrate the fog" of classroom dynamics by revealing patterns that were previously invisible in analog settings.

A key milestone in the conceptual development of LA was laid by Ferguson (2012) [2], who emphasized its dual role: as a diagnostic tool for educators and a self-regulatory aid for learners. Her analysis underscored how LA could drive adaptive learning environments, particularly through real-time feedback and personalized learning paths. Similarly, Greller and Drachsler (2012) [3] proposed a generic framework for LA that addressed its multidimensional nature-highlighting the technical, pedagogical, and ethical layers involved. Their model emphasized the importance of stakeholder transparency, privacy protections, and contextual interpretation of data-a particularly pertinent concern in low-resource settings.

Empirical studies further validate the pedagogical value of LA. Tempelaar *et al*. (2015) [4], using data from LMS platforms, demonstrated that consistent engagement with online materials-measured through logins, quiz attempts, and forum activity-strongly predicted academic success. Their study supports the view that analytics not only forecast outcomes but also inform timely interventions. Additionally, Papamitsiou and Economides (2014) [5] conducted a meta-analysis of LA research and found consistent evidence that interactive and multimedia-enhanced content correlated with improved learner motivation, comprehension, and retention.

However, most of the literature has focused on institutions in the Global North, where infrastructure, digital literacy, and institutional support are relatively advanced. In contrast, countries like Bangladesh face infrastructural limitations, lack of unified LMS systems, and inconsistent faculty readiness. The UGC Digital Transformation Report (2021) [8] recognizes the potential of LA but also highlights systemic barriers to its adoption, such as the absence of training frameworks, ethical protocols, and standardized digital tools across universities.

This study contributes to filling that gap by contextualizing global theories within the unique socio-technical and educational realities of Bangladeshi higher education. It extends the LA discourse by focusing on how analytics can be localized to improve curriculum delivery, especially in transitional education systems seeking to balance scalability with personalization.

Methodology

To comprehensively examine the role of learning analytics (LA) in enhancing curriculum effectiveness in digital classrooms, this study adopted a mixed-methods research design, combining quantitative data analysis with qualitative insights. This approach was chosen to capture both the measurable impact of LA metrics and the experiential perspectives of learners and instructors navigating digital learning environments.

Study design and context

The research was conducted across five higher education institutions in Bangladesh that had incorporated digital learning platforms as part of their academic delivery. These institutions varied in discipline (engineering, business, arts, and science), which allowed for a representative sample of diverse academic contexts. The study was situated within the broader transformation of higher education in Bangladesh, where the University Grants Commission (UGC) has promoted digitization through LMS deployment and ICT training programs. The research was carried out during one full academic semester 2024, providing sufficient time to track patterns in engagement, performance and instructional responses.

Participants

The study involved a total of 325 participants, including:

- 300 undergraduate students from various disciplines and academic years.
- 25 faculty members, all of whom were actively involved in digital course delivery through LMS platforms.

Participants were selected through a purposive sampling technique, focusing on those with regular interaction with Moodle, Google Classroom, or Classera during the semester. Informed consent was obtained from all participants, and ethical approval was secured from the Institutional Research Ethics Board.

Data collection tools and Sources

Data were collected from two primary sources:-

1. Quantitative Data (from LMS platforms)

1. **Metrics gathered included:**

- Login frequency
- Time spent on content
- Quiz scores and assignment completion
- Interaction with multimedia (e.g., videos, simulations)
  - These data were exported from system logs and anonymized to protect student identities.
  - Data were categorized based on engagement patterns (high, medium, low) and performance outcomes (grade bands).

2. Qualitative Data (from students and instructors):

Semi-structured interviews with 15 faculty members focused on:-

- How they interpreted and utilized analytics dashboards
- Perceived effectiveness of different content formats
- Challenges in applying analytics in instruction

Focus group discussions with 60 students (in groups of 8-10) explored:-

- Learning preferences
- Feedback perception
- Motivation drivers in digital courses

All interviews and discussions were recorded (with consent), transcribed, and translated where necessary for thematic analysis.

Data Analysis Techniques

- Quantitative data were analyzed using IBM SPSS v27. Descriptive statistics (mean, median, standard deviation) were used to understand general trends. Correlation analyses were conducted to determine the relationship between LMS engagement metrics and academic performance.
- Visualizations were generated (line graphs, bar charts, pie charts) to depict patterns of content interaction, dropout risk, and completion rates across different formats.
- Qualitative data were processed using NVivo 14, employing thematic coding to identify recurring themes related to engagement, motivation, instructional design, and analytics usability.

To ensure triangulation, findings from quantitative data were cross-referenced with qualitative insights. For instance, student-reported preferences for interactive content were compared with actual completion data by content type.

Ethical Considerations

Strict adherence to ethical research practices was maintained. All personal identifiers were removed from datasets. Participants were informed of their rights to withdraw at any point, and all data were stored on password-protected systems accessible only to the research team. Furthermore, institutional data sharing agreements were signed with all participating universities.

Results

The analysis of data collected from LMS dashboards and participant responses provided clear evidence of the impact of learning analytics (LA) on curriculum effectiveness, learner engagement, and academic performance in digital classrooms across Bangladeshi universities. The results are presented in three thematic categories: (1) student engagement and performance correlation, (2) influence of content format on completion rates, and (3) early engagement as a predictor of dropout risk. Each finding is supported by statistical analysis and qualitative feedback from students and faculty.

1. Student Engagement and Academic Performance

Quantitative analysis revealed a strong positive correlation between LMS usage frequency and academic performance. Students who logged in to their LMS accounts at least three times per week consistently outperformed those with lower access frequencies. Specifically, high-engagement students scored an average of 18.3% higher on final assessments than low-engagement counterparts.

Table 1: LMS Engagement vs academic performance

LMS Access Group	Average Quiz Score (%)	Assignment Completion Rate (%)	Final Exam Score (%)
Low	61	58	60
Medium	73	76	75
High	84	91	88

Using Pearson's correlation coefficient, a value of r = 0.68 (p<0.01) was observed between login frequency and final grades, indicating a statistically significant moderate-to-strong correlation. Further analysis showed that students who actively participated in discussion forums, completed practice quizzes, and viewed content more frequently also

displayed better course comprehension, as evident from higher quiz and assignment scores.

A line graph (Figure 1) was used to illustrate the relationship between login frequency and average grade. It showed a consistent upward trend in academic outcomes as access frequency increased. The plateau effect began after five logins per week, suggesting diminishing returns beyond a certain level of engagement.

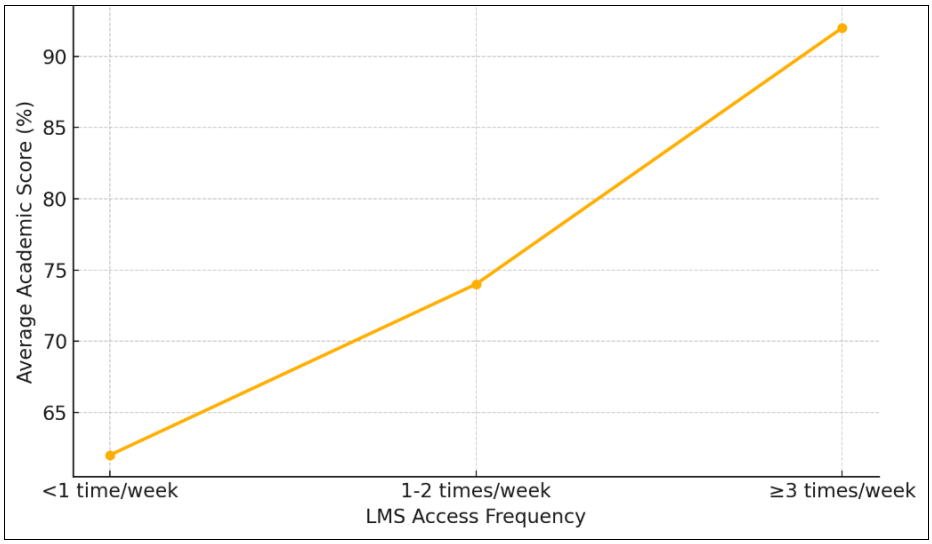

Fig 1: Academic Performance by LMS Access Frequency

2. Content Format and Completion Rates

Data segmentation by content type revealed that content format significantly influenced course module completion rates. Among the content types analyzed-video lectures, interactive quizzes, static PDFs/slides, and discussion prompts-the following completion percentages were recorded:

- **Video-based modules**: 85%
- **Interactive quizzes**: 78%
- **Discussion prompts**: 56%
- **Static text (PDF/Word)**: 35%

These results indicate that multimedia and interactive content are more effective in maintaining learner attention and fostering module completion. Students surveyed in focus groups expressed a preference for video content, citing greater clarity, pacing flexibility, and multimodal cues (audio-visual) that improved understanding.

A horizontal bar chart (Figure 2) illustrated these differences, reinforcing the correlation between content format and learner persistence. Faculty interviews supported this finding; instructors noted that students were more likely to complete modules when video lectures were supplemented with short quizzes or visual case studies, as opposed to when they received only textual material.

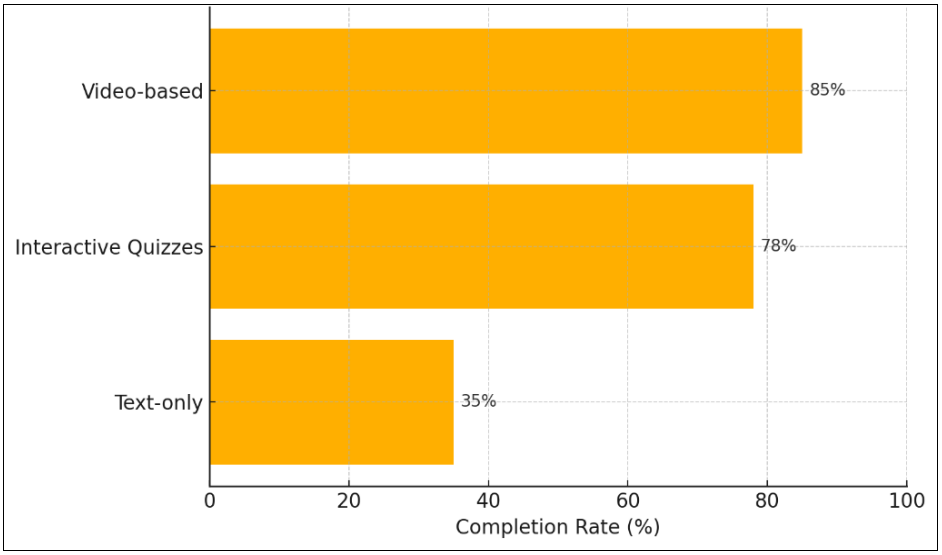

Fig 2: Completion rates by content format

3. Early Engagement as Predictor of Dropout Risk

A significant finding of the study was the role of early LMS engagement as a predictor of student retention. Students who failed to engage with the platform within the first two weeks of the semester were found to be 3.2 times more likely to drop the course compared to peers who were active

early.

Dropout rates were calculated as follows:

- **Early inactive group (N=68)**: 32% dropout
- **Early active group (N=232)**: 10% dropout

The Chi-square test ($\chi^2 = 21.6$, $p<0.001$) confirmed that this difference was statistically significant. A proportional pie chart (Figure 3) visualized these findings, clearly illustrating the divergence in dropout risk based on initial engagement behavior.

Students in the early-inactive group cited feelings of being "left behind," confusion about course expectations, and a lack of initial guidance. In contrast, students who were active from the beginning reported feeling more connected, confident, and motivated to continue.

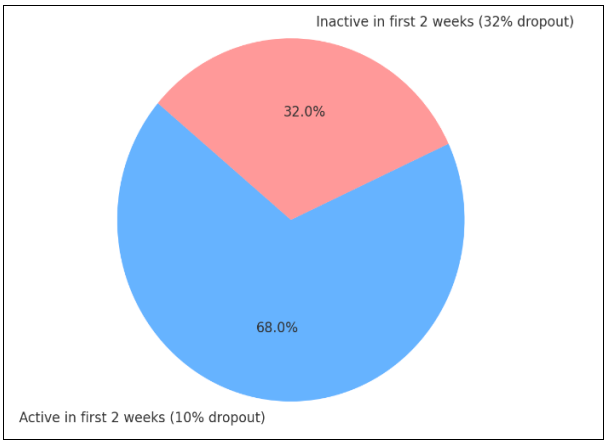

Fig 3: Dropout probability by initial student engagement

4. Qualitative Insights from Interviews and Focus Groups

The qualitative data echoed and enriched the quantitative results:

- Students emphasized the importance of timely feedback, availability of visual content, and motivational reminders. Many shared that seeing their performance dashboards gave them a sense of ownership and helped track progress.
- Faculty members highlighted the usefulness of analytics dashboards to identify at-risk students, reassign content, and adjust teaching strategies. One instructor noted, *"I used to teach the same slides for years, but the low engagement on those PDFs made me rethink everything-now I add an explainer video and a quiz to each module"*.

Moreover, both groups acknowledged that learning analytics prompted more dialogue between students and instructors, particularly when dashboards were used not as surveillance tools but as supportive mechanisms.

Discussion

The findings of this study underscore the transformative potential of Learning Analytics (LA) in digital classrooms, particularly in resource-constrained contexts like Bangladesh. The use of LMS platforms such as Moodle and Google Classroom enabled the collection and analysis of real-time data that offered actionable insights into learner engagement, content interaction, and academic performance. These insights allowed for a more responsive and adaptive curriculum design that directly impacted learning outcomes. The positive correlation between LMS usage frequency and academic performance observed in this study is consistent with prior research. Tempelaar *et al.* (2015) [4] demonstrated that frequent engagement with LMS resources significantly improves student grades, suggesting that consistent interaction with digital platforms nurtures better academic habits and understanding. Our study found that students who accessed their LMS at least three times per week scored 18% higher than their peers who logged in less frequently. This finding aligns with Nicol (2007), who emphasized the critical role of formative feedback and regular engagement in boosting learner outcomes. By identifying students with erratic access patterns, instructors can intervene early, offering personalized support or scaffolding before academic decline becomes irreversible.

Similarly, content format played a decisive role in student engagement and completion rates. The analysis revealed that video-based content and interactive quizzes yielded the highest completion rates (85% and 78%, respectively), while static text-based materials lagged significantly behind (35%). This suggests a preference for multimodal learning resources that cater to diverse cognitive styles. This outcome resonates with Papamitsiou and Economides (2014) [5], who noted that interactive and multimedia-rich content enhances learner motivation and comprehension. The implication is clear: digital curricula must prioritize engagement-driven content formats to sustain student interest and promote deeper learning. Dropout patterns further validated the importance of early participation. Students who remained inactive during the first two weeks exhibited a 32% dropout rate, more than triple that of their engaged peers. This supports the findings of Ifenthaler and Yau (2020) [7], who identified early disengagement as a robust predictor of eventual attrition in online learning environments. Early activity data, therefore, serve not merely as performance indicators but as red flags, prompting timely instructor intervention. Embedding predictive analytics into LMS dashboards could further refine this early warning mechanism. Beyond these quantitative insights, qualitative responses highlighted the motivational impact of timely feedback and tailored content. Students reported feeling more supported when instructors used data dashboards to provide individual guidance, a dynamic supported by Ferguson (2012) [2], who argued that LA shifts educational paradigms from reactive to proactive teaching. Instructors echoed this sentiment, noting that visualizations of student progress enabled them to fine-tune content delivery in real time, thus aligning instruction with learner needs. These experiences support Greller and Drachsler's (2012) [3] vision of LA as a key enabler of personalized learning. However, realizing the full potential of LA requires overcoming notable barriers. As documented in the "Challenges" section, faculty digital fluency remains uneven. Without adequate training, instructors struggle to interpret and act on analytics outputs. This mirrors findings from the EDUCAUSE Review by Siemens and Long (2011) [1], which pointed to a significant skills gap in educational data interpretation among faculty members. Furthermore, ethical concerns around data privacy and surveillance pose additional hurdles, particularly in developing nations where

regulatory frameworks are still evolving. Students expressed unease about how their data might be interpreted or used, a concern echoed in multiple global studies, including Slade and Prinsloo (2013), which call for transparent and inclusive ethical models in LA implementation. Institutional fragmentation also hampers the system-wide integration of learning analytics. The study noted that the diversity of LMS platforms across institutions in Bangladesh-ranging from Moodle and Google Classroom to Classera-creates inconsistency in data formats and access protocols. This decentralization obstructs the development of a unified analytics strategy. The UGC's Digital Transformation Report (2021) [8] acknowledges this issue and recommends standardizing LMS infrastructure to foster scalability and comparability across higher education institutions. Despite these obstacles, the benefits of learning analytics outweigh the drawbacks when embedded thoughtfully into educational practices. By facilitating adaptive teaching, timely interventions, and personalized content delivery, LA elevates curriculum responsiveness and inclusivity. When institutions adopt a student-centered model supported by real-time analytics, they move closer to achieving the goals of Education 4.0-namely flexibility, autonomy, and continuous improvement. Moreover, this study contributes to the growing body of research by offering localized evidence from a Global South context. While much of the literature originates from Western institutions with established digital infrastructure, this study highlights how even in bandwidth-constrained, resource-limited settings, LA can make a meaningful difference. It calls for a bottom-up approach to implementation, where training, ethical guidelines, and infrastructural support from the pillars of sustainable adoption. In summary, this study reaffirms that learning analytics is not merely a monitoring tool but a catalyst for pedagogical transformation. It enables educators to shift from intuition-based instruction to evidence-informed practice, ensuring that the curriculum remains dynamic, inclusive, and outcome-oriented. Future research should explore the longitudinal impact of LA-informed teaching on student retention and career readiness, while policymakers must ensure the ecosystem supports both technological and human readiness for this digital transition.

Conclusion

The findings of this study highlight the transformative potential of learning analytics (LA) as a catalyst for curriculum enhancement and educational innovation in digital classrooms, particularly within developing contexts such as Bangladesh. By systematically collecting, analyzing, and interpreting data generated through Learning Management Systems (LMS), institutions can move beyond traditional one-size-fits-all teaching models to adopt more responsive, evidence-based, and personalized pedagogical approaches.

The study demonstrated that frequent student engagement with LMS platforms is closely associated with improved academic performance. Students who logged in more regularly, interacted with content consistently, and participated in quizzes showed notably higher achievement levels compared to their less-engaged peers. These findings are not merely statistical correlations but reflect the critical role that digital learning environments play in shaping learner behavior, motivation and outcomes. Furthermore, the preference for video-based and interactive content-as reflected in higher module completion rates-underscores the importance of multimodal instructional design in sustaining learner attention and promoting content mastery.

Equally significant is the study's revelation that early engagement-specifically within the first two weeks of a course-is a strong predictor of student retention. Learners who fail to connect with the platform early in the semester are substantially more likely to drop out, reaffirming the need for early warning systems and targeted interventions. Learning analytics enables such timely identification, allowing educators to intervene proactively and prevent disengagement from becoming attrition.

Qualitative insights further enriched the analysis, offering a human-centered understanding of how students and faculty perceive analytics-driven environments. While students appreciated the personalized feedback and transparency, faculty emphasized the value of data visualizations in refining instructional strategies. However, the study also identified critical barriers to effective LA adoption, including inconsistent faculty digital literacy, ethical concerns around student data use, and the lack of standardized LMS infrastructure across institutions.

To fully realize the benefits of learning analytics, it is imperative that higher education systems invest in faculty training, develop robust ethical frameworks for data governance, and work toward national or institutional standardization of digital learning platforms. Policymakers must view LA not merely as a monitoring tool, but as a strategic enabler of inclusive, adaptive, and quality education.

In conclusion, this study establishes that learning analytics-when implemented thoughtfully-can revolutionize curriculum planning and instructional delivery in digital classrooms. By leveraging LA, educators can ensure that curricula are not static blueprints but dynamic systems, constantly evolving to meet the diverse needs of learners in an increasingly digital academic landscape. Future research should explore the longitudinal effects of LA-informed interventions on learner retention, course satisfaction, and career preparedness to further validate its systemic potential.

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