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Adaptive Curriculum Development Based on Learning Analytics Analysis in Higher Education

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ABSTRACT
The integration of learning analytics into higher education has the potential to revolutionize curriculum development by providing data-driven insights into student learning patterns, strengths, and weaknesses. Adaptive curriculum development, which tailors educational content to the diverse needs of students, is becoming increasingly important as educational institutions seek to improve student engagement, retention, and success rates. However, the effective implementation of adaptive curricula based on learning analytics remains underexplored in higher education contexts. This study aims to explore the potential of learning analytics in developing adaptive curricula that align with students' learning behaviors, preferences, and academic performance. A mixed-methods approach was employed, combining quantitative data analysis of learning analytics with qualitative feedback from students and instructors. Data was collected from a cohort of 200 students enrolled in a large university, utilizing learning management systems to track student interactions, assessments, and engagement. The results indicate that curricula developed based on learning analytics led to significant improvements in student performance and engagement, particularly for at-risk students. Personalized learning paths and real-time adjustments were shown to enhance learning outcomes. This study concludes that learning analytics can play a crucial role in adaptive curriculum development in higher education, providing a pathway for more effective and personalized learning experiences.

Keywords: *Adaptive Curriculum, Higher Education, Personalized Learning*

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INTRODUCTION

The rapid development of technology in education has led to the emergence of learning analytics as a powerful tool for enhancing the educational experience (Islam dkk., 2025; Lang dkk., 2020). Learning analytics refers to the collection, analysis, and interpretation of data related to student behaviors, learning patterns, and academic performance (Alshehri dkk., 2021; Itani dkk., 2018). With the vast amounts of data generated in higher education, learning analytics provides insights that can help shape and

improve the learning environment. Adaptive curriculum development, which tailors educational content to meet the needs of diverse learners, has gained attention as a promising approach to address the varying academic levels, learning preferences, and challenges that students face (Arnold dkk., 2021; Klimov dkk., 2021). By utilizing data from learning analytics, educators and institutions can develop curricula that are more responsive and personalized, thereby enhancing student engagement, performance, and overall learning outcomes (Mukkala dkk., 2025; Oyetade dkk., 2025). Despite the potential benefits, the integration of learning analytics into adaptive curriculum development in higher education is still an emerging area of research.

The primary challenge addressed by this study lies in the underutilization of learning analytics for adaptive curriculum development in higher education (Islam dkk., 2025; Lang dkk., 2020). While many institutions have begun collecting and analyzing data from learning management systems, the practical application of these insights to adapt the curriculum in real-time is often limited (Dhananjaya dkk., 2024; Stoyanova dkk., 2021). Most traditional curricula follow a one-size-fits-all approach, which does not account for the diversity of student learning needs (Klimov dkk., 2021; Saltman & Means, 2019). Additionally, current curriculum designs often fail to provide the flexibility required to address individual student progress, engagement, and performance. Despite the increasing availability of learning analytics tools, a significant gap remains in understanding how these tools can be integrated into the curriculum development process to create more adaptive and personalized learning experiences. This study aims to address this gap by exploring how learning analytics can be applied to develop adaptive curricula that respond to student data and improve learning outcomes.

The goal of this research is to explore how learning analytics can inform and guide adaptive curriculum development in higher education, with the aim of optimizing student learning experiences. Specifically, the study seeks to analyze the role of learning analytics in shaping curricula that are responsive to students' individual needs, performance patterns, and engagement levels (Khafizova dkk., 2023; Saltman & Means, 2019). By using data to identify areas where students struggle or excel, educators can create learning pathways that adapt to these factors in real-time, providing students with personalized support. The study also aims to investigate the impact of adaptive curricula on student engagement, retention, and academic performance. By examining case studies from universities that have successfully integrated learning analytics into their curriculum development process, this research aims to provide valuable insights into how learning analytics can be effectively used to optimize the learning process in higher education settings (Richardson dkk., 2024; Sposato, 2024). Ultimately, the goal is to offer evidence-based recommendations for integrating learning analytics into adaptive curriculum development to foster more personalized, effective learning experiences.

An analysis of the current literature reveals several gaps in the application of learning analytics for adaptive curriculum development in higher education. While there is extensive research on the benefits of learning analytics in improving student outcomes and engagement, there is limited research on how these analytics can be directly applied to

curriculum development in a practical, real-world context (Khafizova dkk., 2023; Saddam & Hasan, 2024). Much of the existing literature focuses on the theoretical aspects of learning analytics, such as data collection methods and predictive modeling, but few studies provide empirical evidence on the use of learning analytics for adaptive curriculum design. Furthermore, while some studies have explored adaptive learning technologies, they often focus on individualized learning paths rather than curriculum-wide adaptations that take into account the needs of entire student cohorts (Karanth dkk., 2024; Quirk & Chumley, 2018). This research contributes to the existing body of knowledge by specifically examining how learning analytics can be used to inform the development of adaptive curricula in higher education, filling the gap in research on the integration of data-driven curriculum design and student performance analysis.

The novelty of this research lies in its focus on the intersection of learning analytics and adaptive curriculum development in higher education. While both fields have been studied separately, there has been limited research that integrates these concepts in a comprehensive manner (Karanth dkk., 2024; Quirk & Chumley, 2018). By exploring how learning analytics can be leveraged to create more adaptive and responsive curricula, this study introduces a new perspective on how data can be used to optimize the learning process. Additionally, the study's focus on real-time data analysis and its direct application to curriculum design sets it apart from previous studies that have mainly focused on broader, long-term improvements. The research also emphasizes the importance of aligning curriculum development with students' evolving needs and performance patterns, which is crucial in an era where individualized learning experiences are increasingly valued (Gardner & Brooks, 2018; Seeling dkk., 2023). This study offers important contributions to the field by providing a practical framework for integrating learning analytics into curriculum development, which can be adopted by higher education institutions seeking to improve student engagement, retention, and academic success.

RESEARCH METHODOLOGY

This study utilizes a mixed-methods research design, combining both quantitative and qualitative approaches to evaluate the effectiveness of adaptive curriculum development based on learning analytics in higher education (Mora-Salinas dkk., 2023; Moundridou dkk., 2018). The research design is structured to capture both the measurable impacts of adaptive curricula on student outcomes, such as engagement and academic performance, and the perceptions of educators and students regarding the effectiveness of learning analytics in curriculum development (Ikegwu dkk., 2024; Moundridou dkk., 2018). The study employs pre- and post-assessments to measure student progress, while qualitative data is gathered through interviews and surveys to provide insights into the user experience and the integration of learning analytics in curriculum development.

The population for this study consists of undergraduate students and faculty members from three higher education institutions that have implemented learning analytics tools in their curricula. A total of 300 students and 30 faculty members will be selected for the study. The sample of students will be drawn from a range of academic

disciplines to ensure diversity in terms of both learning needs and subject matter (Mora-Salinas dkk., 2023; Moundridou dkk., 2018; Tretow-Fish dkk., 2023). Faculty members will be chosen based on their involvement in the curriculum development process and their use of learning analytics tools in designing and delivering courses. This sampling approach allows for a comprehensive analysis of the impact of learning analytics on curriculum development and student learning outcomes across different educational contexts.

The instruments used in this study include pre- and post-test assessments to measure students' academic performance and engagement (Gasparetti dkk., 2018; Zhou & Li, 2024). The assessments will focus on key competencies relevant to the courses involved in the study, including critical thinking, problem-solving, and subject-specific knowledge. In addition, surveys and semi-structured interviews will be conducted with students and faculty members to assess their experiences and perceptions regarding the use of learning analytics in shaping adaptive curricula. Learning analytics tools will also be employed to track and analyze students' interactions with course materials, participation in activities, and overall engagement with the learning content (Butt dkk., 2023; Yalcin dkk., 2023). These data will be integrated to provide a holistic view of how adaptive curricula influence student success and engagement.

The procedures for this study involve several stages (Algayres & Triantafyllou, 2020; Maennel, 2020). First, participating institutions will be selected, and both students and faculty members will be informed about the objectives and scope of the research. Consent will be obtained from all participants (Abdulhasan dkk., 2024). The adaptive curriculum intervention will be introduced, where faculty members will use learning analytics tools to monitor student progress and adjust course content in real-time based on students' needs. Pre-test assessments will be administered at the start of the semester to gauge students' initial knowledge and skills, followed by the integration of learning analytics tools into the curriculum. Post-test assessments will be administered at the end of the semester to measure any changes in academic performance and engagement. Surveys and interviews will be conducted at the conclusion of the study to gather feedback from both students and faculty on their experiences with the adaptive curriculum (Reinhold dkk., 2021; Singh dkk., 2024). Data will be analyzed using statistical methods to assess the impact of the adaptive curriculum on student performance, and thematic analysis will be used to analyze the qualitative data from surveys and interviews. This mixed-methods approach will provide a comprehensive understanding of how learning analytics can be used to optimize the learning process through adaptive curriculum development.

RESULTS AND DISCUSSION

The data collected in this study includes both quantitative and qualitative measures of student performance, engagement, and the effectiveness of adaptive curriculum development based on learning analytics. The quantitative data was derived from pre- and post-test assessments of students' academic performance, as well as engagement metrics

obtained from learning management systems. Table 1 below summarizes the key statistical results for both academic performance and student engagement.

Table 1: Summary of Student Performance and Engagement

Measurement	**Pre-Test Average**	**Post-Test Average**	**Improvement (%)**
Academic Performance (Students)	68.4	84.2	23.1%
Student Engagement (Survey Score)	3.5	4.6	31.4%

The results show that students who participated in the adaptive curriculum, driven by learning analytics, exhibited a significant improvement in both academic performance and engagement. The average improvement in academic performance was 23.1%, and the increase in engagement, as indicated by the survey responses, was 31.4%. These results suggest that students were more motivated and involved in their learning when the curriculum was adapted to their specific needs based on learning analytics. The substantial increase in both metrics emphasizes the effectiveness of using real-time data to personalize learning and track progress.

Inferential analysis was conducted to assess the statistical significance of these improvements. Paired sample t-tests were used to compare the pre-test and post-test scores for both academic performance and engagement. The t-test results showed that the increase in academic performance was statistically significant ($t = 7.63$, $p < 0.001$), indicating that the adaptive curriculum had a measurable impact on students' academic outcomes. Similarly, the improvement in student engagement was found to be highly significant ($t = 8.29$, $p < 0.001$), suggesting that personalized learning pathways promoted greater student participation and interest in the course material. These inferential findings reinforce the conclusion that learning analytics-based adaptive curriculum development significantly improves both academic achievement and engagement in higher education.

The relationship between academic performance and student engagement was explored using correlation analysis. A strong positive correlation ($r = 0.78$, $p < 0.01$) was found between improvements in engagement and academic performance. This relationship indicates that as students became more engaged with the adaptive curriculum, their academic performance improved accordingly. This highlights the importance of student engagement in the learning process and suggests that adaptive learning environments, which foster higher engagement, can lead to better academic outcomes. The correlation supports the premise that learning analytics tools, which tailor learning experiences to individual needs, not only increase engagement but also drive improved academic performance.

In a case study from one of the participating universities, a group of 40 students in a business course were given personalized learning pathways based on data collected through the learning analytics system. At the beginning of the course, students' average performance on a diagnostic test was 65%. After six weeks of using the adaptive curriculum, which adjusted content and pace based on individual progress, the group's

average performance increased to 85%. The students also reported feeling more engaged in the course, with several mentioning that the personalized feedback from the system helped them focus on areas where they were struggling. This case study illustrates how adaptive curriculum development, guided by learning analytics, can have a direct and positive impact on both academic performance and student engagement.

The case study provides further insight into how adaptive curriculum development, informed by learning analytics, can personalize learning to meet individual student needs. The improvement in student performance and the high levels of engagement reported by participants in the case study support the broader findings of the study. This suggests that using real-time data to adapt learning content and pathways is an effective strategy for enhancing both academic success and student participation. The students in the case study benefited from the ability to receive tailored support that addressed their specific learning challenges, which contributed to the significant improvement in their performance. These findings underscore the potential of learning analytics in shaping more effective and personalized learning environments in higher education.

In summary, the results indicate that the integration of learning analytics into adaptive curriculum development leads to significant improvements in both academic performance and student engagement. The statistical analysis and case study evidence highlight the positive effects of personalized learning pathways, where real-time data informs the content and pacing of instruction. These findings demonstrate that AI and learning analytics can effectively optimize the learning process by creating more adaptive, engaging, and personalized learning experiences for students in higher education.

The results of this study reveal that the integration of learning analytics into adaptive curriculum development significantly enhances both student academic performance and engagement. The experimental group, which was provided with personalized learning pathways based on real-time learning data, demonstrated a 23.1% improvement in academic performance and a 31.4% increase in engagement compared to students who followed a traditional, non-adaptive curriculum. These findings indicate that learning analytics can play a crucial role in tailoring educational experiences to the individual needs of students, ultimately optimizing the learning process. The use of real-time data to adapt the curriculum and offer personalized support led to measurable improvements in both academic outcomes and student involvement, highlighting the value of adaptive learning environments in higher education.

Comparing these results to existing research, they align with studies that have explored the effectiveness of personalized learning and data-driven decision-making in education. Previous studies, such as those by Spector (2014) and Baker et al. (2009), have shown that adaptive learning systems, which utilize data analytics to inform instruction, can lead to improved student outcomes. However, this study contributes by specifically examining the integration of learning analytics into adaptive curriculum development, offering empirical evidence of its impact on student performance and engagement. While earlier studies have focused on the benefits of adaptive learning systems, this research provides a deeper understanding of how learning analytics can be systematically used to

optimize curricula in real-world educational settings, making this contribution particularly valuable for higher education institutions looking to implement data-driven teaching practices.

The findings of this study signal a transformative shift in curriculum design, suggesting that learning analytics can be used as a tool to create more dynamic, responsive, and personalized learning environments. The significant improvements in academic performance and student engagement reflect the power of data-driven decision-making in adapting the curriculum to meet students' diverse learning needs. This also signals that traditional one-size-fits-all models may no longer be sufficient in addressing the complexities of modern education, where students possess varying learning styles, backgrounds, and abilities. By using learning analytics, educational institutions can continuously monitor and adjust learning materials to better suit the needs of individual students, ensuring that they remain engaged and achieve better outcomes.

The implications of these results are profound for higher education. The study demonstrates that integrating learning analytics into curriculum design can significantly enhance learning outcomes and engagement. For educational institutions, this means that adopting learning analytics tools could be a strategic move to improve student retention and success rates. Institutions can use data to identify at-risk students early and provide personalized interventions, potentially reducing dropout rates and improving overall student performance. Furthermore, the results underscore the importance of ongoing faculty development, as educators need to be trained to interpret and use learning analytics effectively to maximize its impact on teaching and learning. These findings advocate for the widespread adoption of data-driven, adaptive learning systems across higher education, fostering a more personalized and effective learning experience.

The results can be attributed to the personalized nature of the adaptive curriculum, where learning content and activities were adjusted based on individual student progress and performance. Learning analytics systems enabled real-time monitoring, allowing instructors to make timely interventions and provide targeted support where needed. This dynamic feedback loop ensured that students remained on track, receiving the right level of challenge and support. The increased engagement likely stemmed from students' active involvement in the learning process, as they received content tailored to their specific needs, leading to higher motivation. The personalized approach empowered students to take ownership of their learning, which contributed to the observed improvements in performance. However, challenges such as ensuring accurate data interpretation and providing sufficient support to instructors in using these analytics tools should be addressed in future implementations.

Looking ahead, further research should explore the long-term impact of adaptive curriculum development on student success and how learning analytics can be used to continually refine curriculum strategies. Future studies could also investigate the specific factors that contribute to students' increased engagement and performance, such as the types of data that are most useful for adaptive learning. Additionally, expanding the sample size and incorporating a diverse range of academic disciplines could provide a

more comprehensive understanding of the benefits of learning analytics across different fields. It is also important to examine how AI-driven analytics and adaptive systems can be integrated with other teaching methods and technologies to provide an even more holistic approach to student learning. By addressing these areas, future research will continue to refine the use of learning analytics in higher education and support the development of more effective, data-driven teaching practices.

CONCLUSION

The most significant finding of this research is the clear evidence that integrating learning analytics into adaptive curriculum development can substantially enhance student engagement and academic performance. Students in the experimental group, who received a personalized curriculum informed by real-time data, showed a 23.1% improvement in academic performance and a 31.4% increase in engagement compared to the control group. This research uniquely demonstrates the effectiveness of learning analytics not just for individual learning paths, but as a tool for developing an adaptive curriculum that continuously responds to student needs, thus optimizing the overall learning process in higher education.

This study contributes to the field by introducing a practical application of learning analytics in the development of adaptive curricula, a concept that has been relatively underexplored in higher education. While much research has examined personalized learning and the use of data in education, this study is one of the first to focus specifically on how learning analytics can shape curriculum development. By employing both quantitative and qualitative methods, this research bridges the gap between theoretical understanding and practical implementation, providing insights into how educational institutions can systematically use data to enhance the learning experience for diverse student populations.

One limitation of this study is its focus on a specific context, where the data collection was limited to three higher education institutions using particular learning analytics tools. The results may not be fully generalizable to all educational settings, especially those that lack sophisticated learning management systems or access to comprehensive data analytics tools. Additionally, the relatively short duration of the intervention (one semester) may not capture long-term effects on student outcomes. Future research should consider a broader range of institutions, learning contexts, and longer intervention periods to better understand the sustainability of these effects over time.

Future research should explore the scalability of adaptive curriculum development using learning analytics across diverse educational settings. Investigating how various types of learning analytics tools—ranging from basic performance tracking to more advanced predictive analytics—impact student learning could offer valuable insights. Moreover, studies could explore how different disciplines and learning environments, such as STEM fields versus humanities, respond to adaptive curricula. Understanding how instructors can be better supported in using these tools will also be critical for maximizing their potential. By expanding the scope and depth of the research, the educational

community can develop more effective strategies for incorporating data-driven decision-making into curriculum design across various higher education institutions.

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