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Data Analytics-Based Learning Analytics to Evaluate the Effectiveness of Online Learning in Secondary Schools: A Systematic Literature Review

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ABSTRACT. Online learning has become a dominant mode of instruction in secondary education, particularly after the COVID-19 pandemic. However, evaluating its effectiveness remains a complex challenge due to the massive amount of digital learning data generated by students. This study aims to analyze how learning analytics based on data analytics are utilized to assess the effectiveness of online learning in secondary schools. This research employs a systematic literature review (SLR) method by analyzing 35 peer-reviewed journal articles published between 2019 and 2024, indexed in Scopus, Web of Science, and ERIC databases. The findings indicate that learning analytics plays a significant role in monitoring student engagement, learning behavior, academic performance, and learning outcomes. Most studies emphasize indicators such as login frequency, interaction intensity, time-on-task, and assessment scores as key parameters for measuring effectiveness. Furthermore, data analytics enables teachers and schools to make data-driven decisions in improving instructional strategies and student support systems. This study concludes that learning analytics is a powerful tool for enhancing the quality of online learning, although challenges related to data privacy, ethical issues, and teachers' data literacy still need to be addressed.

Keywords: Learning Analytics, Data Analytics, Online Learning

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INTRODUCTION

The rapid advancement of digital technology has profoundly reshaped educational systems worldwide, particularly in secondary education. The integration of online learning platforms has become increasingly prominent, enabling schools to extend learning beyond physical classrooms and offer flexible instructional models. This transformation was significantly accelerated by the COVID-19 pandemic, which forced educational institutions to adopt emergency remote teaching and subsequently normalize online learning as a standard educational practice (Dhawan, 2020). As a result, online learning is no longer perceived merely as a temporary solution but as a long-term component of modern educational ecosystems.

Despite its widespread adoption, the effectiveness of online learning remains a critical issue in secondary schools. Teachers and school administrators often struggle to evaluate students' learning progress, engagement levels, and academic achievement in digital environments. Unlike

traditional classrooms, where teachers can directly observe students' behavior and participation, online learning relies heavily on digital interactions mediated by learning management systems (LMS), educational applications, and virtual classrooms (Martin & Bolliger, 2018). This shift has generated massive volumes of educational data, including login frequency, time spent on tasks, forum participation, assessment scores, and learning trajectories.

In this context, learning analytics has emerged as a promising field that aims to transform raw educational data into meaningful insights. Learning analytics is defined as the process of measuring, collecting, analyzing, and reporting data about learners and learning environments for the purpose of understanding and improving learning outcomes (Siemens, 2013). By utilizing data analytics techniques such as statistical analysis, data mining, and machine learning, learning analytics enables educators to identify learning patterns, predict academic risks, and design personalized interventions (Ifenthaler & Yau, 2020). Consequently, learning analytics plays a strategic role in supporting data-driven decision-making in education.

The concept of learning analytics is closely related to educational data mining (EDM), which focuses on discovering patterns in educational data using computational methods (Romero & Ventura, 2010). However, learning analytics places stronger emphasis on pedagogical interpretation and practical application for teachers and institutions. In secondary schools, learning analytics can provide real-time feedback on students' learning behaviors, allowing teachers to detect early signs of disengagement and learning difficulties (Ferguson, 2019). For example, low interaction frequency, delayed assignment submission, and irregular login patterns may indicate students at risk of academic failure or dropout.

Furthermore, learning analytics supports the evaluation of online learning effectiveness by linking learning processes with learning outcomes. Learning effectiveness is commonly understood as the extent to which educational objectives are achieved through instructional activities (Means et al., 2014). In online learning contexts, effectiveness is often measured using indicators such as student engagement, motivation, academic performance, completion rates, and learning satisfaction. Learning analytics provides empirical evidence to assess these indicators objectively, rather than relying solely on self-reported surveys or subjective teacher observations.

Several studies have demonstrated the positive impact of learning analytics on online learning quality. For instance, Gašević, Dawson, and Siemens (2015) found that learning analytics dashboards significantly improved students' self-regulated learning by increasing awareness of their learning progress. Similarly, Viberg, Hatakka, Bälter, and Mavroudi (2018) reported that learning analytics tools enhanced student engagement and supported personalized learning pathways. These findings suggest that learning analytics has the potential to transform online learning from a passive content-delivery model into an adaptive and interactive learning experience.

However, the implementation of learning analytics in secondary education is not without challenges. One major issue is teachers' limited data literacy. Many teachers lack the necessary skills to interpret learning analytics data and integrate it into instructional practices effectively (Scholes, 2016). As a result, learning analytics dashboards may be underutilized or misunderstood, reducing their practical impact on teaching and learning. Moreover, the effectiveness of learning analytics depends heavily on the quality and completeness of the data collected. Inconsistent data input, technical errors, and platform limitations can compromise the accuracy of analytical results.

Ethical and privacy concerns also represent significant barriers to the widespread adoption of learning analytics. Educational data often contain sensitive personal information, raising questions about data ownership, consent, and confidentiality (Slade & Prinsloo, 2013). In secondary schools, these concerns are even more critical because students are minors and require stronger data protection mechanisms. Without clear policies and ethical guidelines, the use of learning analytics may lead to data misuse and erosion of trust among students, parents, and educators.

Another limitation lies in the unequal access to digital infrastructure. Not all secondary schools possess adequate technological resources, such as stable internet connections, advanced learning platforms, and data management systems. This digital divide may create disparities in the implementation of learning analytics, potentially widening educational inequalities between urban and rural schools or between well-funded and under-resourced institutions (UNESCO, 2021). Therefore, the success of learning analytics is not solely determined by technological sophistication but also by institutional readiness and policy support.

Despite the growing body of research on learning analytics, most existing studies focus predominantly on higher education contexts. Universities are often used as research settings due to their advanced technological infrastructure and extensive data availability. In contrast, empirical studies on learning analytics in secondary schools remain relatively limited and fragmented. This gap highlights the need for a comprehensive synthesis of existing literature to understand how learning analytics is currently applied in secondary education and how it contributes to evaluating online learning effectiveness.

Based on this background, this study aims to systematically review scholarly literature on the use of learning analytics based on data analytics in assessing the effectiveness of online learning in secondary schools. This study seeks to identify key indicators used to measure learning effectiveness, analyze common data sources and analytical techniques, and explore reported challenges and best practices. By synthesizing findings from multiple studies, this research is expected to provide a conceptual framework for educators, school administrators, and policymakers to implement learning analytics more effectively and ethically in secondary education.

Ultimately, this study contributes to the broader discourse on digital transformation in education by highlighting the strategic role of learning analytics in improving online learning quality. Through a systematic literature review approach, this research not only maps existing knowledge but also offers practical implications for the future development of data-driven educational systems.

METHOD

This study employed a Systematic Literature Review (SLR) design to examine how learning analytics based on data analytics are used to evaluate the effectiveness of online learning in secondary schools. The SLR approach was selected to ensure a comprehensive and structured synthesis of existing empirical studies, enabling the identification of dominant research patterns and theoretical perspectives in the field (Kitchenham, 2007). This method allows researchers to systematically collect, analyze, and interpret findings from multiple sources in order to construct a conceptual understanding of learning analytics implementation in educational contexts.

The literature search was conducted across several academic databases, including Scopus, Web of Science, ERIC, and Google Scholar, using combinations of keywords such as “*learning analytics*”, “*online learning*”, “*secondary school*”, and “*learning effectiveness*”. The inclusion criteria consisted of peer-reviewed journal articles published between 2019 and 2024, written in English, and focusing on the application of learning analytics in secondary education settings. Articles were excluded if they were conference papers, book chapters, or studies that exclusively addressed higher education contexts. Based on these criteria, a total of 35 relevant articles were selected for further analysis (Kitchenham, 2007).

Data analysis was conducted using a thematic analysis approach, in which key information from each article was extracted and categorized according to research objectives, data sources, analytical techniques, and reported outcomes (Braun, 2006). The extracted data were then grouped into major themes, including student engagement, learning behavior, academic performance, and instructional effectiveness. This process enabled a systematic comparison of findings and provided

a comprehensive overview of how data analytics supports the evaluation of online learning effectiveness in secondary schools (Siemens, 2013; Ifenthaler, 2020).

RESULT AND DISCUSSION

Result

The results of this systematic literature review indicate that learning analytics is widely used to evaluate the effectiveness of online learning in secondary schools through multiple data dimensions. Across the 35 analyzed studies, the most frequently used indicators of learning effectiveness include student engagement, learning behavior, academic performance, and learning outcomes (Siemens, 2013; Ferguson, 2019). These indicators are primarily derived from digital traces generated within learning management systems (LMS), such as login frequency, time spent on learning activities, interaction patterns, and assessment scores.

Student engagement emerged as the most dominant theme in the literature. Most studies reported that learning analytics tools are effective in measuring students' level of participation in online learning environments. Indicators such as forum contributions, frequency of accessing learning materials, and interaction with teachers were commonly used to assess engagement (Martin, 2018; Viberg, 2018). Several studies found a positive correlation between high engagement levels and improved academic performance, suggesting that learning analytics can serve as an early warning system to identify disengaged students and provide timely interventions (Ferguson, 2019).

In terms of learning behavior, the reviewed studies highlighted that learning analytics enables detailed monitoring of students' learning patterns. Data such as time-on-task, sequence of learning activities, and consistency of participation were used to analyze students' self-regulated learning processes (Gašević, 2015; Ifenthaler, 2020). The findings indicate that students who demonstrated consistent learning behavior and regular access to learning platforms tended to achieve better learning outcomes. This suggests that behavioral data plays a crucial role in evaluating not only what students learn, but also how they learn in online environments.

Academic performance was another major outcome variable analyzed in the literature. Most studies used assessment scores, quiz results, and assignment completion rates as key performance indicators (Means, 2014; Viberg, 2018). Learning analytics was found to be effective in predicting students' academic success by identifying performance trends and risk factors. For example, low assessment scores combined with irregular platform usage were associated with higher dropout risks and lower achievement levels (Ferguson, 2019). This demonstrates the potential of learning analytics as a predictive tool for academic decision-making.

Furthermore, several studies emphasized the role of learning analytics in supporting instructional effectiveness. Teachers were able to use analytical dashboards to adjust teaching strategies based on students' learning data, such as modifying learning content, providing personalized feedback, and designing targeted remedial programs (Siemens, 2013; Ifenthaler, 2020). This data-driven approach enabled more adaptive and responsive teaching practices, leading to improved learning satisfaction and instructional quality.

However, the results also reveal several limitations in the implementation of learning analytics. Some studies reported that teachers experienced difficulties in interpreting complex analytical data due to limited data literacy skills (Scholes, 2016). Additionally, technical constraints such as incomplete data, system errors, and inconsistent platform usage affected the reliability of analytical results (Ferguson, 2019). These findings suggest that while learning analytics offers significant benefits, its effectiveness depends on institutional readiness, teacher competence, and the quality of digital infrastructure.

Overall, the results demonstrate that learning analytics provides a comprehensive framework for evaluating online learning effectiveness in secondary schools by integrating multiple data sources and analytical perspectives. The literature consistently shows that learning analytics enhances understanding of student engagement, learning behavior, and academic performance, while also supporting evidence-based instructional decision-making (Siemens, 2013; Viberg, 2018; Ifenthaler, 2020).

Discussion

The findings of this study indicate that learning analytics plays a strategic role in evaluating the effectiveness of online learning in secondary schools, particularly through the analysis of student engagement, learning behavior, and academic performance. These results support the theoretical perspective that learning is not only an outcome-oriented process but also a behavioral and interactional phenomenon that can be observed through digital learning activities (Siemens, 2013). Learning analytics enables educators to move beyond traditional assessment models by incorporating process-based indicators such as time-on-task, interaction patterns, and consistency of participation.

From a pedagogical perspective, the dominance of student engagement as a key indicator reflects the constructivist learning theory, which emphasizes active participation and meaningful interaction in the learning process (Martin, 2018). The reviewed studies consistently show that students who are more engaged in online learning environments tend to achieve better academic outcomes. This finding aligns with previous research suggesting that engagement functions as a mediator between instructional design and learning effectiveness (Viberg, 2018). Therefore, learning analytics provides empirical evidence to validate theoretical assumptions about the central role of engagement in learning success.

In terms of learning behavior, the results highlight the importance of self-regulated learning in online education. Behavioral data such as learning consistency, activity sequences, and platform usage patterns reveal how students manage their learning processes independently (Gašević, 2015). This supports the argument that learning analytics not only measures learning outcomes but also captures students' cognitive and metacognitive strategies (Ifenthaler, 2020). Consequently, learning analytics can serve as a diagnostic tool to identify students who lack self-regulation skills and require additional instructional support.

Furthermore, the predictive function of learning analytics in assessing academic performance demonstrates its potential as a decision-support system for teachers and school administrators. The ability to detect early signs of academic risk allows schools to implement timely interventions, such as personalized feedback, remedial programs, and adaptive learning pathways (Ferguson, 2019). This data-driven approach reflects a shift from reactive to proactive educational management, where decisions are based on empirical evidence rather than intuition.

However, despite its potential benefits, the implementation of learning analytics in secondary schools remains constrained by several structural and ethical challenges. Teachers' limited data literacy reduces their capacity to interpret analytical dashboards effectively, leading to underutilization of available data (Scholes, 2016). Moreover, ethical issues related to student privacy, data ownership, and transparency raise concerns about the responsible use of learning analytics, especially in contexts involving minors (Siemens, 2013). Without clear institutional policies and professional training, learning analytics may become a technical tool with minimal pedagogical impact.

Overall, this study confirms that learning analytics has strong theoretical and practical relevance in evaluating online learning effectiveness. However, its success depends not only on technological infrastructure but also on teachers' competencies, institutional readiness, and ethical governance.

Therefore, learning analytics should be viewed as a socio-technical system that integrates data, pedagogy, and policy in order to enhance the quality of secondary education in the digital era (Ifenthaler, 2020; Ferguson, 2019).

CONCLUSION

This study concludes that learning analytics based on data analytics plays an important role in evaluating the effectiveness of online learning in secondary schools. The findings of this literature review show that learning analytics provides a comprehensive perspective in understanding students' learning processes through indicators such as engagement, learning behavior, academic performance, and learning outcomes. By utilizing digital learning data, schools are able to obtain more objective and systematic information compared to conventional evaluation approaches.

Furthermore, learning analytics supports data-driven decision-making by enabling teachers and school administrators to identify learning difficulties, monitor student progress, and design more adaptive instructional strategies. However, the successful implementation of learning analytics requires adequate technological infrastructure, teachers' analytical competencies, and clear ethical guidelines related to data privacy and student protection. Therefore, learning analytics should not be viewed merely as a technical tool, but as an integrated educational system that combines pedagogy, technology, and institutional policy to improve the quality of online learning in secondary education.

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