Learning Design and Learning Analytics to Improve Higher Education: A Systematic Literature Review

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Abstract: In recent years, higher education has increasingly emphasized the integration of Learning Design and Learning Analytics to foster more engaging, personalized, and effective learning environments. This systematic literature review investigates how these two domains interact to enhance teaching learning processes and improve educational outcomes. The review identifies key benefits and opportunities associated with this integration across three stakeholder groups: students, lecturers, and educational institutions by analyzing 55 peer-reviewed publications. The results show that learning effectiveness can be significantly enhanced through the visualization of students' learning interactions using straightforward and user-friendly analytical approaches. Furthermore, successful implementation requires the development of lecturers' data literacy and programming competencies, as well as the incorporation of sociocultural, psychological, and physical data to achieve a more holistic understanding of learners. The review also identifies four major research directions to guide future efforts in bridging Learning Analytics and Learning Design. Finally, the paper underscores the importance of establishing clear ethical and privacy frameworks to ensure the responsible application of Learning Analytics in higher education.

Keywords: Learning analytics, Learning design, Technology-enhanced learning, Higher education, Learning analytics dashboards

1. Introduction

Learning is a process that changes how individuals understand themselves and the world around them (Looney and Siemens 2011). It allows students to gain new knowledge, improve their skills, and adapt their behaviors. Students participate in both formal and informal learning. Informal learning is often self-directed, peer-supported, and rooted in everyday practice, producing outcomes that can be flexible or unexpected (Nicolae, Mihai and Stefan 2019). In contrast, formal learning takes place in schools, universities, and other educational institutions, guided by structured curricula, defined goals, and formal assessments (Nicolae, Mihai and Stefan 2019).

In universities, tools like wikis, blogs, video conferencing systems, discussion forums, and MOOCs are commonly used to promote active learning. While these tools offer significant benefits, challenges such as low pass rates or unsatisfactory learning outcomes sometimes arise. One major reason is that the design of learning activities, commonly referred to as Learning Design (Craft and Mor 2012), may not align well with the intended learning outcomes. Lecturers often lack direct feedback on how students engage with these activities, making it difficult to refine and improve Learning Design in future iterations.

Learning Analytics provides a solution by analyzing student data to offer insights into engagement and performance. Learning Management Systems can collect detailed records of students' activities, which Learning Analytics can process to generate actionable insights in real time. By combining Learning Design and Learning Analytics, lecturers can better understand student behaviors, evaluate the effectiveness of their learning activities, and make evidence-based improvements.

This study focuses on identifying the benefits of combining Learning Design and Learning Analytics and highlighting opportunities to improve higher education through better assessment of learning activities and visualization of student's engagements.

This paper is structured as follows. Section 2 reviews the theoretical background of Learning Design and Learning Analytics, as well as their interrelationship. Section 3 outlines the research questions and describes the methodology employed in the study. Section 4 presents the results of the literature review, and Section 5 discusses the findings and offers concluding remarks.

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2. Background

Both Learning Design and Learning Analytics aim to enhance the learning environments and improve the effectiveness of the learning process. Sharing a common aim increases the potential to have a synergy between these two domains (Mangaroska and Giannakos 2017). On the one hand, the outputs generated by well-formulated Learning Analytics tools can provide valuable information to lecturers and learning designers about the outcomes, success, and effectiveness of their Learning Designs (Alhadad and Thompson 2017; Wise et al. 2016). On the other hand, Learning Designs present domain vocabulary to represent the elements in an educational system where Learning Analytics can be applied. The natural and synergistic relationship that emerges between Learning Analytics and Learning Design has therefore led to the emergence of this fast-growing research area. Different definitions for Learning Design can be found in the existing literature. Ifenthaler and Gibson (2018) extended Dobozy's (2013) Learning Design definition list to further illustrate the roots of Learning Design by including the recent definitional constructs. The most comprehensive and most cited definitions are presented in **Table 1.**

Table 1: Learning Design Definitions

Author(s)	Definition
Agostinho (2006)	*"A learning design is a representative of teaching and learning practice documented in some notational form so that it can serve as a model or template adaptable by a teacher to suit his/her context."*
Conole (2013)	*"A methodology for enabling teachers/designers to make more informed decisions in how they go about designing learning activities and interventions, which is pedagogically informed and makes effective use of appropriate resources and technologies."*
Emin-Martinez et al. (2014)	*"The act of devising new practices, plans of activity, resources and tools aimed at achieving particular educational aims in a given situation."*
Koper (2006)	*"The description of the teaching-learning process that takes place in a unit of learning. The key principle in learning design is that it represents the learning activities and the support activities that are performed by different persons (learners, teachers) in the context of a unit of learning. These activities can refer to different learning objects that are used during the performance of the activities (e.g. books, articles, software programmes, pictures), and it can refer to services (e.g.: forums, chats, wiki's) that are used to collaborate and to communicate in the teaching-learning process."*
Hale (2016)	*"Learning Design is the process of designing learning experiences (planning, structuring, and sequencing) through facilitated activities that are pedagogically informed, explicit, and make better use of technologies in teaching."*

As a summary, Learning Design describes the learning activities, resources required, and the different ways a lecturer can use these to facilitate the learning. These activities are intended to increase student knowledge and skills through interaction with the lecturer, peers, or content items (Marcel et al. 2017). Furthermore, a Learning Design can be reused and customized by other lecturers since Learning Design activities are independent of its implementation context (Dalziel et al. 2016; Hernández-Leo et al. 2014). Most of the research work in the Learning Design field has focused on the creation of tools, practices, and processes, and on sharing their outputs with practitioners. Only a few studies have evaluated the effectiveness of Learning Designs. This highlights the need for methodological approaches capable of assessing learning effectiveness and identifying design elements that need redesign in subsequent iterations, a process in which Learning Analytics can play a critical supporting role.

This underscores the need for methodological approaches capable of assessing learning effectiveness and identifying design elements requiring refinement in subsequent iterations, a process in which Learning Analytics can play a critical supporting role.

Lecturers can use Learning Analytics to evaluate the success and outcomes of their Learning Designs (Lockyer, Heathcote, and Dawson 2013; Melero et al. 2015). Learning Design alone does not provide information on how students engage with the design during and after the course. Learning Analytics fills this gap by providing data during different stages of the course, enabling evaluation of the design and offering a holistic view of its impact (Lockyer, Heathcote, and Dawson 2013). Analytics also support regulation and redesign by highlighting design elements that need revision before reuse (Hernandez-Leo et al. 2014). During delivery, Learning Analytics can identify student behaviours, allowing lecturers to intervene if these differ from expected outcomes. For example, by sending reminders, offering tutorials, or personalising activities. Such information supports targeted

course designs for subgroups of students such as underperforming students, students at-risk, slow learners, or differently abled students (McKenney and Mor 2015; Hansen 2016; Rienties and Toetenel 2016).

At the same time, the need to link analytics approaches and outputs to educational contexts has been widely recognized (Rienties, Toetenel, and Bryan 2015; Gasevic, Dawson, and Siemens 2015). To optimize Learning Analytics for improved student performance and adaptive analysis, the underlying pedagogical context provided by Learning Design must be integrated. Pedagogical plans and objectives from Learning Designs can be appraised against Learning Analytics outputs (Rienties, Toetenel, and Bryan 2015). Without such contextual interpretation, the potential of Learning Analytics is limited (Mangaroska and Giannakos 2017). Learning Design provides this framework, ensuring meaningful analysis of student behavioral data and accurate pedagogical recommendations (Looney and Siemens 2011; Lockyer, Heathcote and Dawson 2013).

Therefore, to enhance higher education, Learning Design and Learning Analytics must be integrated into a coherent cycle. As Ifenthaler, Gibson and Dobozy (2017) observed, one of the next frontiers in Blended Learning research is the synergistic relationship between Learning Design and Learning Analytics.

Different definitions for Learning Analytics can also be found in the literature. The most comprehensive and most cited definitions are given in **Table 2.**

Table 2: Learning Analytics Definitions

Author(s)	Definition
Looney and Siemens (2011)	*"Learning Analytics is the use of intelligent data, learner-produce data, and analysis models to discover patterns and connections within that data, and to predict and advise on learning."*
LAK11 website (2011)	*"Learning Analytics is the measurement, collection, 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."*
Johnson et al. (2011)	*"Refers to the interpretation of a wide range of data produced by and gathered on behalf of students in order to assess academic progress, predict future performance, and spot potential issues."*
Jisc Program (2017)	*"Meeting the challenge of using data and analytics to support students; improving satisfaction, retention and graduation rates."*

The use of Learning Management Systems (LMS), which can store and visually represent student information, enabled the active development of the Learning Analytics field. Learning Analytics apply Data Mining and Machine Learning techniques to identify hidden patterns in LMS data and use information visualization techniques to generate summative, real-time, and predictive feedback to both students and lecturers. For students, Learning Analytics tools provide opportunities for self-evaluation and comparison with peers. For lecturers, these tools provide evidences about students' performance, engagement, potential risks, and the effectiveness of teaching methods. For institutions, analytics support broader decision-making, including student recruitment, curriculum planning, and financial policies (Campbell and Oblinger 2007).

3. Research Methodology

3.1 Purpose of the Systematic Literature Review and Research Questions

The aim of this systematic literature review is to examine and synthesize existing empirical research on the integration of Learning Analytics and Learning Design in higher education. Furthermore, the review seeks to identify the key benefits, challenges, and opportunities arising from this integration. In order to clearly capture the contributions of the Learning Analytics and Learning Design synergy, the following research questions were developed:

RQ1. *What benefits emerge from the integration of Learning Analytics and Learning Design in higher education?*

RQ2. *What opportunities arise from the implementation of synergy between Learning Design and Learning Analytics to enhance teaching and learning in higher education?*

3.2 The Originality of the Literature Review

A search query was formulated with a set of keywords focusing on the targeted research topic to find similar reviews already conducted in this domain (Webster and Watson 2002). Databases such as IEEE Xplore, ACM

Digital Library, Scopus, and Google Scholar were selected for the search. The search query yields four similar literature reviews in the domain, and all reviews were carefully analyzed.

The first research paper, entitled "A review of ten years of implementation and research in aligning learning design with learning analytics at the Open University UK" by Rienties et al. (2017), presented the lessons learned from eight research works conducted on applying Learning Analytics to understand the impact of Learning Designs on student performance, behavior, and satisfaction. However, this review only considered the research works conducted at the Open University UK.

The second research paper, entitled "Learning analytics for learning design: A systematic literature review of analytics-driven design to enhance learning" by Mangaroska and Giannakos (2018), considered how Learning Analytics can support Learning Design. They aimed to investigate the current status of Learning Analytics for Learning Design and classified the Learning Analytics indicators that have been used to inform Learning Design decisions.

The third research paper, entitled "Learning design and learning analytics in mobile and ubiquitous learning: A systematic review" by Pishtari et al. (2020), presented a systematic literature review of Learning Analytics and Learning Design in mobile and ubiquitous learning (M/U-learning) by reviewing 54 papers published in the domain. This literature review was conducted to investigate how M/U-learning, Learning Design, and Learning Analytics are related.

The fourth research paper, entitled "Connecting the dots—A literature review on learning analytics indicators from a learning design perspective" by Ahmad et al. (2022), investigated the role of Learning Design in Learning Analytics through a systematic literature review by analyzing 161 research papers. The aim of this paper is to create a reference framework that connects Learning Analytics and Learning Design and to identify and analyze the Learning Analytics indicators and metrics used over the past decade.

The aim and research questions of our systematic literature review are different from the above literature review papers. To the best of our knowledge, at the time of writing this paper, there were no journal papers or conference publications directly related to our research aim and the research questions.

3.3 Research Process

This study used the eight-step paradigm suggested by Okoli and Schabram (2010) to conduct a systematic literature review. These steps are: (1) Identify the purpose; (2) draft the protocol; (3) apply practical screen; (4) search for literature; (5) extract data; (6) appraise quality; (7) synthesize studies; (8) write the review. All the eight steps are essential for creating a scientifically rigorous systematic literature review (Okoli 2015). The activities undertaken at each of these steps are described below, and **Figure** 1 illustrates the overall systematic literature review process.

Step 1: As mentioned in section 3.1, the purpose of the systematic literature review is to identify empirical evidence that demonstrates the benefits and opportunities that might arise as a result of implementing the synergy between Learning Analytics and Learning Design to enhance higher education.

Step 2: Research protocols were drafted to conduct the literature review, including the following steps.

- Selection of the international databases: IEEE Xplore, ACM Digital Library, Scopus, and Google Scholar.
- The search queries were formulated using the keywords focusing on the targeted research topic. Three main search terms, *'Learning Analytics,' 'Learning Design,'* and *'Higher Education,'* were used.

All search queries contained the above three main terms in combination with the following terms in research paper titles.

('synergy' OR 'alliance' OR 'collaboration' OR 'connect') AND ('education' OR 'teach' OR 'learn', OR 'study success' OR 'retention' OR 'course completion')

- Annotating digital paper copies and linear notes were used as note-taking techniques.

Step 3: The practical screening was applied based on the previously defined inclusion criteria in the research protocol. The literature inclusion criteria of the study are listed below.

- Research studies were positioned in the higher educational context.
- Research papers were either peer-reviewed journal articles or conference papers.
- Presented either qualitative or quantitative analyses and findings.

- Published after 2011.
- Published in the English language.
- An abstract was available.

Step 4: A literature search was conducted based on the keywords mentioned in the protocol. Search queries returned N = 157 publications.

Step 5 & Step 6: These steps were executed in parallel, which includes the following sub-steps.

- An initial search identified N = 157 research papers. After removing irrelevant papers and duplicates, N = 67 papers were discarded, resulting in N = 90 papers retained for abstract-level screening.
- A detailed analysis of the abstracts was performed, focusing on the relevance of key concepts (e.g., Learning Analytics for Learning Design). In this phase, N = 21 papers were excluded, leaving N = 69 papers for full-text review.
- A comprehensive analysis of the full papers was conducted, considering theoretical background, methodology, and experimental evidence. During this stage, N = 14 papers were discarded, resulting in a final set of N = 55 key publications included in the literature review.

Step 7: Relevant information was extracted from the selected research papers by reading the abstract, methodology, experimental results, and pedagogical approaches. Extracted information was coded, summarized, and organized based on the research aim, research questions, research design, and contribution to the domain.

Step 8: Key findings were documented by writing this research paper.

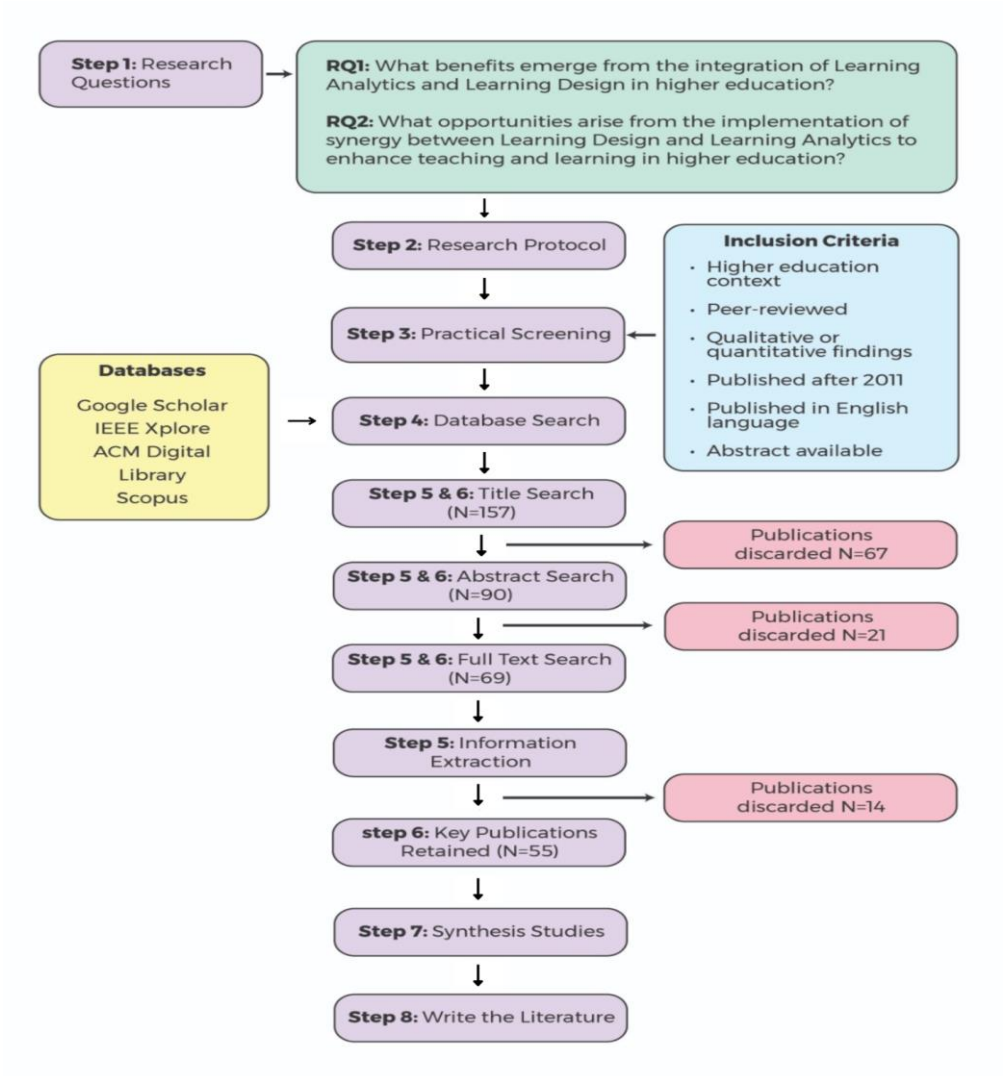

Figure 1: Flow chart of the research process

4. Results

4.1 RQ1: What Benefits Emerge from the Integration of Learning Analytics and Learning Design in Higher Education?

The benefits of using the synergy between the Learning Design and Learning Analytics are associated with three levels: micro-level (students), meso-level (lecturers), and macro-level (higher educational institutions).

Micro Level - Students

According to Rienties and Toetenel (2016), learning is not always an enjoyable experience. Making mistakes and receiving poor grades can make learning challenging at times. As a result, getting positive feedback and assistance is crucial for ongoing learning (Rienties and Toetenel 2016). Learning Analytics visualizations are crucial for boosting students' self-esteem and motivation.

Learning Analytics Dashboard displays facilitate the ongoing enhancement of engagement, performance and satisfaction. While visualizing assignment grades on a line chart encourages students to keep improving, visualizing their engagement with the materials also improves their drive. The combination of Learning Analytics and Learning Design can boost student learning engagement, performance, learning success, career objectives, and retention, according to previous studies (Rienties, Toetenel, and Bryan 2015; Rienties and Toetenel 2016).

According to Ferguson (2012), Mangaroska and Giannakos (2018), the data produced by Learning Analytics tools can boost students' motivation, satisfaction, and confidence. According to Siemens et al. (2011), Mangaroska and Giannakos (2018), students can easily monitor their current progress, identify the subject areas in which they are performing poorly, calculate the time needed for each learning task, and create a customized learning environment based on analytical visualizations. A summary of the important research activities conducted to facilitate students is given in **Table 3.**

Table 3: Summary of research activities conducted to facilitate students.

Author(s)	Year	Aim	LA Methods/ Research Design	Contribution(s)
Rienties, Toetenel and Bryan	2015	How does Learning Design affect performance?	Cluster analysis. Correlation analysis.	Learning Designs strongly influence student engagement and performance.
Atkinson	2015	Empower the learner with their own ability to make adjustments to their self-learning.	Identify student engagement. Visually present using pie charts.	SOLE Model—empowers the Research student to adjust their self-learning environments by using Learning Analytics tools. SOLE toolkit.
Toetenel and Rienties	2016	How do Learning Designs affect LMS behavior, satisfaction, and performance in blended and online environments?	Multiple regression models.	Importance of Learning Designs in predicting and understanding the performance of students.
Toetenel and Rienties	2016	The configuration of Learning Designs and its effect on students' performance.	Cluster analysis. Correlation analysis.	Importance of Learning Designs in LMS behavior and performance.

Author(s)	Year	Aim	LA Methods/ Research Design	Contribution(s)
Wise	2016	How are analytics taken up and used as part of the teaching and learning process?	Focus on students as analytics users.	Student Tuning Model. Align Design framework - a continual cycle model in which students plan, monitor, and change their learning activities as they engage in the learning activities with Learning Analytics.
Schumacher and Ifenthaler	2016	Investigate features students expect from Learning Analytics.	Qualitative exploratory study.	Features students expect are self-assessments, personalized analyses, adaptive recommendations, and support to plan and organize their learning process.
Ifenthaler, Gibson and Dobozy	2017	Demonstrate how analysis could inform Learning Design of the self-guided digital learning experience.	Network graph analysis. Navigation pattern analysis.	Dashboard visualizations provide a self-guided digital learning experience.
Nguyen, Rienties and Toetenel	2017	How was Learning Designs configured longitudinally across modules & what was its effect on LMS behavior?	Visualization Network Analysis. The fixed-effect regression model.	Learning Designs identified the variability in student online activities.
Nguyen, Rienties and Toetenel	2017	How were Learning Designs configured at the activity level, and what media was used to deliver them?	Visualization. Network analysis.	Find out how learning activities interact with each other across modules. Assimilative activities accounted for the majority of study time.
Mavrikis and Karkalas	2017	Increase awareness regarding the use of educational e-books.	Dashboard Visualization.	Reflective Designer Analytics Platform (RDAP) to increase the awareness of the use of e-books.
Charleer et al.	2018	Facilitate communication between study advisers and students by visualizing grade data.	Dashboard Visualization.	LISSA dashboard.
Antonette, Simon and Simon	2019	Develop scalable Learning Analytics applications that can cater to a large number of students.	Design and Creation.	CLAD model for Learning Analytics to align with pedagogical contexts. AcaWriter tool to improve the academic writing of Students.
Wang and Han	2020	Provide process-oriented feedback to students to enhance learning effectiveness.	Dashboard Visualization.	iTutor-Learning Analytics Dashboard.

Author(s)	Year	Aim	LA Methods/ Research Design	Contribution(s)
Vujovic et al.	2020	How the shapes of shared tables affect the learners' behaviour when collaborating in terms of patterns of participation.	Multimodal learning analytics. Quantitative and qualitative analyses.	Use of round tables (vs rectangular tables) leads to higher levels of on-task participation in the case of elementary school students.
Fan et al.	2021	Identify learning tactics and their links with Learning Design elements.	Cluster analysis, process mining technique, and an epistemic network analysis.	Detected four learning tactics (Search oriented, content-and-assessment-oriented, content-oriented, and assessment-oriented) that were used by MOOC learners.
Banihashem et al.	2021	Investigate the effect of the Constructivist Learning Design and Learning Analytics (CLDLA) Model on learners' engagement and self-regulation	Experimental study.	The CLDLA model has a positive impact on learners' engagement and self-regulation.
Duan, Wang and Rouamba	2022	Implement a Learning Analytics Dashboard to generate actionable feedback for students to advance their self-regulated learning skills and improve their grades.	Dashboard Visualization.	Learning Analytics Dashboard.
Jayashanka et al.	2022	Improve motivation, engagement, and grades of students.	Dashboard Visualization.	TELA-System (a Moodle plugin).
Ochukut et al.	2024	Alignment of Learning Design with Learning Analytics in Moodle-based blended learning.	Case study: activity log analysis.	Demonstrated how aligning Learning Designs with Learning Analytics in blended learning improved engagement and completion rates.
Possaghi et al.	2025	Integrate multi-modal Learning Analytics Dashboard in K-12 education.	User-centered design. Multi-modal data analytics.	Developed an LAD for open-ended activities in K-12 settings.

Author(s)	Year	Aim	LA Methods/ Research Design	Contribution(s)
Echeverria et al.	2025	How students from high and low-performing groups reflect individually on their collaborative performance while using a Learning Analytics Dashboard (LAD).	Post-hoc semi-structured individual interview. Bain's 5R reflection framework. Epistemic Network Analysis (ENA).	Use of LADs to provoke reflection must be accompanied by scaffolding strategies. Researchers studying student reflection with Learning Analytics Dashboards should examine not only what and how often students reflect, but also the qualitative depth and stages of their reflection.
Jin et al.	2025	Investigates the role of GenAI literacy in learner interactions with conventional versus scaffolding chatbot-assisted LADs.	2x2 mixed-method experiment. Comparative analysis.	Highlighted the importance of considering learners' GenAI literacy when integrating GenAI chatbots in LADs and educational technologies.
Marques, Hernández-Leo and Castillo	2025	How factors of the educational setting and student performance interplay with student satisfaction with the Learning Design.	Student satisfaction survey. Reliability Assessment Score. Institutional analytics.	Learning Design aspects strongly correlate with students' holistic perception of a course.

Meso level - Lecturers

Feedback from students is typically gathered after learning activities are finished. This makes it impossible for lecturers to intervene in students' learning in real time (Nguyen, Rienties, and Toetenel 2017). The reflection stage of the teaching process is frequently restricted to intuition gleaned from self-reports, course assessments, and evaluations. Real-time interventions may be further limited by response and selection bias in these feedback processes (Nguyen, Rienties, and Toetenel 2017).

By generating feedback that is rich in information, data gathered by Learning Management Systems can empower lecturers and speed up the teaching process. This enables lecturers to make real-time interventions and assess their methods at various granularities (Nguyen, Rienties, and Toetenel 2017). By allowing lecturers to assess the efficacy of Learning Designs and ascertain whether anticipated learning outcomes are attained, the synergy between Learning Analytics and Learning Design facilitates this process. Additionally, these statistics make it easier to identify Learning Design components that need to be revised before being used again.

Learning Analytics data, such as the frequency of subject access or the amount of time spent on learning activities, offer real-time insights into how students respond to a Learning Design (Nguyen, Rienties, and Toetenel 2017). These behavioral indicators enable lecturers to develop tailored interventions, modify lesson plans in response to student trends, spot underachievers early, and offer focused assistance (Law et al. 2017; Hansen 2016; Rienties and Toetenel 2016). To address topics that are difficult to understand, lecturers may also give extra lectures, tutorials, or educational materials.

Learning Design and Learning Analytics work together to promote ongoing enhancements to the quality of instruction. Using analytical visualizations, lecturers can assess teaching methods, engage with students more successfully, and improve autonomy and decision-making. A summarization of the important research activities conducted to facilitate the lecturers is given in **Table 4.**

Table 4: Summary of research activities conducted to facilitate lecturers

Author(s)	Year	Aim	LA Methods/ Research Design	Contribution(s)
Jonathan et al.	2012	Investigate feedback for teaching and learning using analytics via Moodle.	Analyzed: Engagement Involvement Interaction Influence	Implementation of feedback display.
Lockyer, Heathcote and Dawson	2013	How Learning Designs might provide the framework for interpreting Learning Analytics results?	Checkpoint analysis. Process analysis.	Evaluation of learning within a specific pedagogical design. Visualizations provide lead indicators of student engagement and how they progress through the planned learning sequence.
Emin-Martinez et al.	2014	Help teachers to align both the improvement of their practices and the orchestration of their classrooms.	Combines Learning Design and Analytics to improve the adoption and assessment of learning tasks.	Teacher-led design inquiry of learning" as a new model of educational practice and professional development.
Kennedy et al.	2014	Investigate and develop ways in which Learning Analytics can be harnessed by teaching in higher education.	Access new forms of empirical data to teachers.	Conversational Framework - highlighted the interaction, dialogue, and feedback between teachers and students are critical to students' learning process and outcomes. Explore teachers' views on how Learning Analytics might help them address known difficulties. Web-based analytics tool to support teachers.
Rodríguez-Triana et al.	2015	Proposal for alignment between Learning Designs and Learning Analytics to support teachers in designing scenarios.	Scripting. Monitoring.	Exploits the synergies between Learning Designs and Learning Analytics in Computer-Supported Collaborative Learning using monitoring aware design process and script aware monitoring process.
McKenney and Mor	2015	How teachers are supported in the synergistic processes integral to the educational design?	Evaluation of a tool and results of the retrospective analysis.	CASCADE-SEA: A computer-based support tool which provides reflective analysis on Learning Designs.

Author(s)	Year	Aim	LA Methods/ Research Design	Contribution(s)
Hernández-Leo and Pardo	2016	Empower the learner with their own ability to make adjustments to their personal learning.	Articulation of multiple authoring tools.	ILDE community platform to support teachers to design learning activities using multiple authoring tools.
Toetenel and Rienties	2016	The configuration of LD and its effect on students' performance.	Visualization. Correlation analysis.	Seven types of Learning Designs analyzed through Learning Analytics methods. They found out the high focus given for the assimilative and assessment learning activities. Lower usage of student-active activities.
Toetenel and Rienties	2016	Whether collaborative, networked approach changed how educators design courses.	Comparison of 148 prior and post Learning Design initiatives.	By visualizing design upfront, educators focused less on traditional teaching patterns.
Bakharia et al.	2016	Inquiry-based evaluation of Learning Designs.	Temporal Analysis. Tool-specific Analysis. Cohort Analysis. Comparative Analysis	Conceptual Framework—Presents more meaningful data to teachers to evaluate their Learning Designs and to transform Learning Designs into a teacher-led, inquiry-based practice. Loop Tool—the reference implementation of the conceptual framework.
Gunn et al.	2016	Professional development of teachers.	Outlines a professional development initiative.	Make Learning Analytics practice accessible to teachers.
Kitto et al.	2016	Proposes direct solutions for helping people to imagine how Learning Anaytics might be used in a more nuanced manner.	Social network analysis. Content analysis.	CLA Toolkit - uses xAPI to unify the description of data gathered from various media. Three Learning Design patterns to support Learning Analytics protocols.
Nguyen, Rienties and Toetenel	2017	How was Learning Designs configured longitudinally across modules & what was its effect on LMS behavior?	Visualization Network Analysis. Fixed-effect regression model.	Learning Designs identified variability in student online activities. Learning Designs able to explain up to 60% of the variability in student online activities.

Author(s)	Year	Aim	LA Methods/ Research Design	Contribution(s)
Law et al.	2017	Support inter-professional collaboration among learning designers and Learning Analytics communities.	Design and creation.	Learning Design Studio (LDSHE) to facilitate interprofessional collaboration among learning designers and Learning Analytics communities.
Nguyen, Rienties and Toetenel	2017	How were Learning Designs configured at the activity level, and what media was used to deliver them?	Visualization. Network Analysis.	Assimilative activities accounted for majority of study time. Lecturers more likely to use reading materials to convey information.
Marcel et al.	2017	Improve the Learning Design of a course during run-time.	Design Science Research.	Learning Analytics Dashboard.
Inventado and Scupelli	2017	Encourage collaboration among existing communities of stakeholders.	Four objectives for online learning collaboration.	Online learning collaborator framework to encourage collaboration among stakeholders.
Mavrikis and Karkalas	2017	Increase awareness regarding the use of educational e-books.	Dashboard Visualization.	Reflective Designer Analytics Platform (RDAP) - developed for lecturers and designers to support the creation of interactive e-books for learning.
Eradze, Rodríguez-Triana and Laanpere	2017	Introducing observational data into Learning Analytics datasets to provide a more holistic view of the teaching and learning process.	Research-based design process.	Reference Model. Observata—lesson observational tool.
Davinia Hernández-Leo et al.	2018	Propose a framework to support informed decision-making in Learning Design.	Design a framework with three layers of Data Analytics: — Learning Analytics, Design Analytics, and Community Analytics.	AL4LD framework.
Xing et al.	2019	Employ Learning Analytics to build performance prediction models to help struggling students.	Radial Basis Function-based Support Vector Machines and the tree classification method.	Develop a model to identify struggling students and provide actionable insights for teachers to provide personalized and timely feedback to students.

Author(s)	Year	Aim	LA Methods/ Research Design	Contribution(s)
Kaliisa, Kluge and Mørch	2020	Investigate how Learning Analytics can inform Learning Designs in Blended Learning environments.	Social Network Analysis. Text Network Analysis.	Analyzing different levels of analytics could provide important information about student online learning processes, which can be used as a reflective resource by teachers to make informed Learning Designs decisions.
Wang and Han	2020	Provide process-oriented feedback to students to enhance learning effectiveness.	Dashboard Visualizations.	iTutor-Learning Analytics Dashboard.
Nguyen et al.	2021	Develop, demonstrate, and evaluate a set of design principles for Information Systems (IS) that utilize Learning Analytics to support learning and teaching in higher education.	Design Science Research Methodology.	Established a foundation for further development and implementation of Learning Analytics Information Systems (LAIS) in higher education.
Mohseni, Martius and Masiello	2021	Explore the design of a Learning Analytics Dashboard with the use of interactive visualizations and Machine Learning.	Data Visualizations.	SAVis tool.
Stoyanov and Paul	2023	Aims to identify the most relevant concepts at the intersection of Learning Designs and Learning Analytics.	Critical interpretive synthesis. Qualitative content analysis. Text analytics.	Identified two topics rarely explicitly discussed in the literature: 'evidence-informed instructional design approaches' and 'design-based research.'
Pelizzari, Sala and Tassalini	2024	Pilot implementation of Learning Analytics in Higher Education for teaching improvement.	Case study. Data infrastructure. Role-based dashboards.	Demonstrated Learning Analytics positive impact on teaching practices, early risk detection, and institutional decision support.

Author(s)	Year	Aim	LA Methods/ Research Design	Contribution(s)
Liu et al.	2024	Assist K-12 teachers in assessing students' collaborative problem solving skills in an educational game.	Survey. Partial Least Squares Structural Equation Modelling (PLS-SEM).	A Learning Analytics Dashboard was implemented to assist K-12 teachers. Makes theoretical, methodological, and practical contributions to technology integration in Learning Analytics Dashboard implementation.
Possaghi et al.	2025	Integrate multi-modal Learning Analytics Dashboard in K-12 education.	User-centered design. Multi-modal data analytics.	Developed an Learning Analytics Dashboard for open-ended activities in K-12 settings.
Alenezi and Alenezi	2025	Applies data analysis to the improvement of online course design.	Descriptive analytical approach employing mixed method. Survey.	Learning Analytics possess substantial potential to transform online course design and foster better student outcomes.

Macro Level – Higher Educational Institutes

Curriculum creation and the launch of new academic programs can benefit from the data produced by the synergy between Learning Analytics and Learning Design. Furthermore, learner cohort analysis, lower dropout rates, improved student retention, and overall academic achievement can all be achieved with the use of such data (Ifenthaler and Widanapathirana 2014). Applications at the institutional level have received very little attention, despite the fact that the majority of current research focuses on the advantages at the student and lecturer levels. This shows a glaring research gap and emphasizes the need for further empirical studies that look at how higher education institutions might strategically use Learning Analytics in line with Learning Design to guide long-term planning and decision-making. The observed benefits may be methodically traced across three hierarchical levels because the main stakeholders mentioned in the literature are students, lecturers, and higher education institutions (Ifenthaler and Widanapathirana 2014). This classification makes it easier to find research gaps and allows for an organized assessment of the benefits of this synergy. The benefits found in the literature are summarized in Table 5 by mapping them across three hierarchical stakeholder levels: students (micro-level), lecturers (meso-level), and higher education institutions (macro-level).

Table 5: Benefits of synergy between Learning Analytics and Learning Design for different stakeholders

Stakeholder	Benefits
Student	Check current performance level. Indicate key materials to learn. Facilitate the creation of a personalized learning environment. Indicate subject areas need to improve. Visualize the required amount of study time. Track the progress towards learning goals. Increase engagement. Improve grades. Improve motivation and self-confidence. Optimize learning activities.

Stakeholder	Benefits
Lecturer	Increase the quality of teaching. Identify students at-risk of failure/underperforming students. Adjust the learning materials to the needs of the learners. Create meaningful interventions. Modify the Learning Designs to meet cohorts' needs. Compare Learning Designs. Identify Learning Designs that need to revise. Evaluate Learning Materials. Plan for future interventions.
Higher Educational Institutes	Adjustments of the curriculum to the needs of learners. Increase the quality of the curriculum. Optimize resource allocation. Model retention rates. Support to take financial decisions. Minimize the dropout rates.

A methodical evaluation of how Learning Analytics and Learning Design work together to serve various players in the higher education is made possible by this organized classification. Fewer empirically confirmed benefits are documented at the institutional level, despite a significant number of benefits being reported at the student and lecturer levels. This gap emphasizes the narrow focus of earlier research on macro-level outcomes including strategic decision-making, curriculum-wide optimization, and policy formation rather than suggesting a lack of potential benefit for higher education institutions. As a result, **Table 5** serves as an analytical tool to discover unexplored regions and direct future research on Learning Analytics-informed Learning Design applications at the institutional level, in addition to summarizing recognized benefits.

4.2 RQ2: What Opportunities Arise from the Implementation of Synergy Between Learning Design and Learning Analytics to Enhance Teaching and Learning in Higher Education?

The systematic literature review reveals four primary opportunity areas emerging from the integration of Learning Analytics and Learning Design. These opportunities signify a shift from intuition-based teaching to evidence-informed, adaptive, and ethically governed educational practices. The following section provides a detailed examination of each of these four opportunity areas.

- Making Learning Designs more reliable for lecturers and students

The participatory involvement of all stakeholders in the learning community is important in planning suitable practices to implement design models and the tools to support them (Emin- Martinez et al. 2014; Matcha et al. 2019). There is a growing need to establish an online repository of Learning Designs that can be accessible by a wide educational community. Also, it is important to implement a participatory culture in the field of Learning Design (Emin-Martinez et al. 2014; Persico and Pozzi 2015). Learning Design helps lecturers to describe, communicate, and share their designs with the Learning Design community. Good teaching practices from one educational context can be captured and reused in another context (Lockyer, Heathcote, and Dawson 2013). By sharing Learning Designs within the Learning Design community, the lecturers can comprehend whether their particular design or model leads to an effective learning experience for the learner. At the same time, lecturers should be encouraged to review peer Learning Designs and provide feedback.

In current learning environments, students' feedback is collected after studying the course module. Rienties et al. (2017) highlighted the importance of getting the involvement of students' participation in the Learning Design activities. Open University's Learning and Teaching Innovation curriculum design student panel is a novel approach to get the students' contribution to the model development using focus groups (Rienties et al. 2017).

Recently, design patterns have been suggested as a construct to mediate between Learning Design and Learning Analytics (Inventado and Scupelli 2015). The Learning Analytics community needs to create a pattern repository to support lecturers as a source of inspiration when creating new course content (Kitto et al. 2016). Design patterns should support the transfer of the currently available effective Learning Designs to other learning

contexts without reinventing the wheel (Antonette, Simon, and Simon 2019). Research work that has been conducted in terms of the practices, tools, and representations to evaluate the effects of Learning Designs is limited. Learning Design needs to incorporate built-in evaluation methods to analyze whether the expected outcomes were achieved. Lecturers should be able to generate designs that are compatible with emerging Learning Analytical technologies and tools (Atkinson 2015). Lecturers need to design units of learning that can be deconstructed and rebuilt in meaningful ways to enable the Learning Analytic algorithms to function optimally (Atkinson 2015).

- Design and implementation of smart Learning Analytics tools

The design and development of smart Learning Analytics tools that can provide summative, real-time, and predictive feedback to students, lecturers, and educational institutes is another opportunity in this domain (Matcha et al., 2019; Valle et al., 2021). These tools and frameworks play a vital role when creating a synergy between Learning Designs and Learning Analytics, which in turn provides benefits to enhance higher education. As stated in **Table 3** and **Table 4,** researchers developed different technologies (tools, frameworks, and models) to enhance the learning environments through the synergy between Learning Analytics and Learning Design. However, most of those tools are in the development and experimental stages. The opportunities that arise related to the design and implementation of smart Learning Analytic tools are mentioned below.

The first opportunity is about the data and the environment. There is a growing need to develop methods to work with a wide range of datasets, shift towards more challenging datasets, and combine datasets which include mobile data, biometric data, and mood data to improve learning environments. Benefits of Learning Analytic tools can improve by using the physical data which are not directly linked with educational data, such as the student's current emotional state, self-confidence, demographic, and socio-cultural data (Rienties, Toetenel and Bryan, 2015; McKenney and Mor, 2015). The implementation of tools and analytic methods to handle big data and deliver real-time meaningful results is also important.

The second opportunity is about defining the right objectives/indicators/metrics triple before the implementation of Learning Analytics tools. Focusing on objectives concerning the learners' perspectives is essential to the development of tools related to learners' needs, rather than the needs of institutions (Ferguson, 2012; Williamson and Kizilcec, 2022). These perspectives can extend the criteria for learning success beyond grades and persistence to include motivation, confidence, satisfaction, and meeting career goals (Williamson and Kizilcec, 2022).

The third opportunity is to develop tools that can easily be used for analysis and visualizations without having extensive knowledge of the techniques underlying these tools. It is important to consider the requirements of both students and lecturers when designing and implementing analytic tools. Both lecturers and students can easily understand simple dashboard visualizations (Valle et al., 2021; Matcha et al., 2019). It is really important to keep in mind that students are different and unique when designing and implementing Learning Analytics tools. Students can be empowered to use his/her own ability to refine their learning environment by using Learning Analytics tools (Atkinson, 2015). It is important to improve the usability of analytic tools and create user manuals and guidelines to build a good interaction between the users (lecturers and students) and the analytic tools.

- Professional Development of Lecturers

The need to improve the use of “learning intelligence” in lecturers is becoming urgent due to an interdisciplinary space between computer researchers and lecturers (Melero et al. 2015; Celik and Magoulas 2016). Lecturers are curious about experimenting with new methods to integrate Learning Analytic tools with Learning Designs. For this, they have to improve their programming skills needed to develop such technologies (Celik and Magoulas 2016). They frequently underrate the potential of data science, since they remain unaware of the different methods by which educational datasets can be analyzed and visualized (Celik and Magoulas 2016). Therefore, it is essential to increase data literacy among lecturers (Melero et al., 2015). Professional development, training, incentives, and rewards are critical for the successful adoption of Learning Analytics tools (Cathy et al., 2016). Cathy et al. (2016) presented Learning Analytics professional development scenarios, and they highlighted the importance of expertise to support lecturers to develop their data literacy skills (Cathy et al. 2016).

- Development of a clear set of ethical guidelines

Another opportunity that emerges when implementing the synergy between Learning Design and Learning Analytics is ethical, legal, and risk considerations. The development and application of a clear set of ethical

guidelines are important. Under this, data accuracy, how to respect privacy, maintaining anonymity, preventing data misuse, protecting confidential user information, data ownership, data preservation, sharing data with outside parties, and proper training for educational practitioners regarding the handling of data should be taken into consideration.

Figure 2 provides a graphical summary of the key findings from this Systematic Literature Review, highlighting the benefits and opportunities resulting from the integration of Learning Analytics and Learning Design.

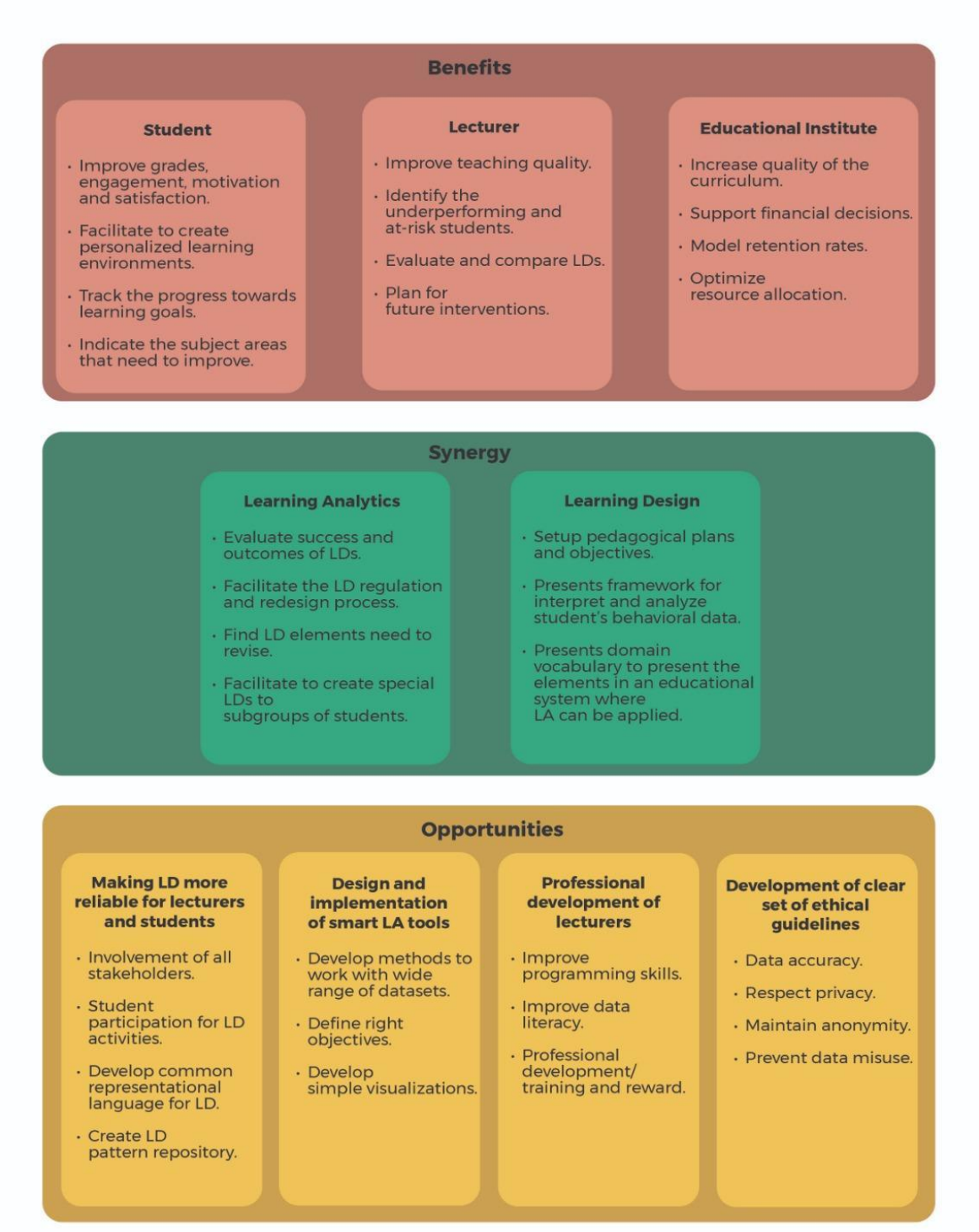

Figure 2: Benefits and Opportunities Arise as a Result of implementing the Synergy Between Learning Analytics and Learning Design

5. Conclusion

By incorporating computer technologies into teaching methods, universities are increasingly encouraging their faculty to innovate. This comprehensive literature review investigated the relationship between Learning Analytics, the use of data science in educational settings, and Learning Design, the framework for creating interactive learning experiences. Our analysis demonstrates a synergistic relationship: Learning Analytics produces the empirical evidence needed to assess and improve Learning Designs, while Learning Designs supply the instructional goals and semantic framework.

This systematic literature review found important advantages for students, lecturers, and higher-educational institutions based on a thorough analysis of 55 systematically selected research papers. Self-Regulated Learning models (like SOLE toolkit), decision-making frameworks (like AL4LD), and engagement dashboards (like TELA-System) are important contributions. Additionally, putting this synergy into practice offers four transformative opportunities: Making Learning Designs more reliable for lecturers and students, Design and implementation of smart Learning Analytics tools, Professional Development of Lecturers, and Development of a clear set of ethical guidelines.

Notwithstanding these developments, the analysis identifies a number of crucial topics that require further research. There is an urgent need to implement intelligent and interactive Learning Analytics Dashboards for students that provide real-time feedback and support customized learning pathways, as the majority of existing tools remain lecturer-centric. Additionally, there is still a lack of study on the use of advanced AI, such as Artificial Neural Networks, Deep Learning and Generative AI to enhance learning environments.

Future studies should also use sensing technologies that record affective characteristics, such as student motivation and emotion, in addition to typical clickstream data. Lastly, research addressing the macro-level requirements of higher-educational institutions and national policy formulation is conspicuously lacking, despite the well-documented micro-level benefits of classrooms. The long-term development of analytics-informed Learning Designs in higher education will depend on filling in these gaps and creating explicit ethical standards for data protection.

AI Statement: The authors declare that they used ChatGPT and Grammarly to enhance the spelling, language quality, and overall readability of this manuscript.

Ethical Declaration: This study did not require ethical approval because it is a Systematic Literature Review based exclusively on previously published scholarly sources. The research did not involve the collection of privacy data, nor did it include any interaction with human participants or animals. Consequently, no personal, sensitive, or identifiable data were accessed or analyzed.

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