Review of Learning Analytics Dashboards for Students

Krishnavamsi Gujju*, Sahithi Bandi, and Marcia Moraes

Department of Computer Science, Colorado State University, USA
{krish15, sahithi.bandi, marcia.moraes}@colostate.edu

Abstract. In our comprehensive literature review, we systematically explored the impact of Learning Analytics Dashboards (LADs) on student engagement, motivation, and academic performance within higher education settings. Utilizing a methodical approach, we selected and analyzed 21 studies that met our inclusion criteria focusing on diverse research designs, sample sizes, and outcome measures. Our methodology involved a rigorous evaluation of studies to understand the depth of LAD's effects on various student populations and learning environments. The results revealed that LADs could significantly enhance student engagement and motivation, leading to improved academic performance. However, the findings also underscored a pressing need for further research into the design and implementation of these dashboards, highlighting the importance of addressing challenges like information overload and the necessity for dashboards to cater to different student demographics. This literature review offers valuable insights into the effective design and implementation of learning dashboards, proposing that future LAD developments should prioritize user-centric designs to maximize learning outcomes and enrich the educational experience in higher education.

Keywords: Learning Analytics, Learning Analytics Dashboard for Students, Feedback, Design, Learning Management System and Development.

1 Introduction

Learning Analytics (LA) has emerged as an influential force in education, owing to the digital revolution and the exponential growth of data from online learning settings (Scheinman et al. [2]). The discipline exists at the crossroads of data analysis and educational reform, with the goal of using vast streams of data to adapt learning experiences and improve student results (Matcha et al. [1]). LA's growth is a direct response to the demand for more adaptable and individualized teaching approaches, and it reflects a broader movement toward evidence-based, learner-centered education (Bodily et al. [3]). Dashboards, a key tool in LA, have been designed to convert complex data into actionable insights, allowing educators and students to make educated decisions (Pan et al. [4]; Dorados et al. [5]).

The evolution of LA is distinguished by its emphasis on optimizing the learning process through data-driven tactics. LA's role in education goes beyond data gathering to include critical analysis and reporting of student interactions to support the

educational ecosystem (Kia et al. [6]; Valle et al. [7]). LA has become a vital ally for educators as digital tools become more integrated in learning and teaching, offering a granular view of student engagement and performance (Ley et al. [8]; Wang et al. [9]). Furthermore, LA dashboards are becoming more well acknowledged for their ability to promote self-regulated learning and provide tailored feedback (Love et al.[10]; Teasley et al. [11]). As the field matures, it is apparent that LA will continue to be at the vanguard of educational innovation, influencing the future of learning in the digital age (Lim et al. [12]; Achaea et al. [13]).

Learning Analytics Dashboards (LADs) have become a potent tool in the rapidly evolving educational landscape, offering students insightful information about their personal learning journeys. Drawing from the fields of Learning Analytics, Data Analytics, and Artificial Intelligence, LADs are designed to provide students with data visualizations and feedback. While these tools aim to support real-time decision-making, it is important to recognize that there may be inherent delays in data synchronization and updates. For example, educational platforms like Canvas might reflect analytics with a delay, such as a 24-hour lag. Despite this, LADs remain invaluable for fostering self-regulated learning by helping students monitor and reflect on their progress with the most current data available. Wang et al. [9] mentioned as students navigate the complex world of online education platforms and digital learning environments, LADs offer a promising avenue for enhancing academic performance, motivation, and metacognitive skills. This research will conduct a thorough investigation of LADs designed for students, diving into their essential features, functionalities, and impact on learning outcomes. Our goal is to gain knowledge to inform the design and development of more effective and user-centric LADs that can alter students' educational experiences. In order to do that, this paper aims to answer the following research questions:

RQ-1: What key features and functionalities were identified in a learning analytics dashboard for students to improve their learning outcomes?

RQ-2: Among the features identified in the literature, which ones are related to self-regulated learning?

RQ-3: Do studies in the literature demonstrate any positive outcomes in terms of improving student behavior and learning outcomes?

This literature review systematically gathers state-of-the-art information on Learning Analytics Dashboards (LADs) for students, highlighting key developments, impacts, and future directions in educational technology. Our analysis of 21 pivotal studies offers a comprehensive overview of LADs' roles in enhancing student learning experiences and identifies critical areas for further research and development.

2 Methodology

In the initial phase of this project, we conducted a literature review to comprehensively understand the landscape of Learning Analytics Dashboards (LADs). This review was essential to gather recent insights, identify research gaps, and lay the groundwork for subsequent work. We established specific criteria for choosing relevant studies papers. The inclusion criteria included research on LA and LADs that were published in peer-reviewed journals or conference proceedings between 2017 and 2023. We also considered research that looked at previous evaluations of the literature on LADs, emphasizing viewpoints, experiences, impact, and effectiveness. Exclusion criteria involved non-peer-reviewed articles, publications before 2017, and duplicate or redundant studies. The databases utilized for the literature review included IEEE Xplore, ACM Digital Library, Wiley Online Library, Springer, and Google Scholar.

In our initial step, we explored IEEE Xplore, utilizing advanced search capabilities. We employed keywords "Learning," "Analytics," and "Dashboard" while restricting the publication years to the range of 2017 to 2023. The search for "Learning Analytics Dashboard" produced an initial result of 4,961 papers. To focus exclusively on literature reviews, we extended our query by adding "literature review," which led to 350 results. From this selection, we examined the titles for relevance to our research focus. For those that seemed pertinent, we read the abstracts to further assess their applicability, ultimately choosing 3 papers that were most relevant for detailed analysis. We applied a similar approach to the ACM Digital Library. The initial search with the same parameters returned 2,375 results. By focusing on literature reviews pertaining to LAD, we scrutinized the titles and abstracts for relevance, which allowed us to identify and select 3 papers that closely matched our research objectives. The same method was employed for the Wiley Online Library, which presented us with 3,468 results. Again, we filtered these results by examining paper titles and abstracts, using the same keywords and timeframe. This process enabled us to discern the 3 most pertinent papers related to student-centered LAD for a more in-depth review.

In the second phase of our research, we refined our search strategy to focus specifically on LADs tailored for student use. Employing a set of detailed keywords including "Learning," "Analytics," "Dashboard," "Literature Review," and "Students," we conducted searches across IEEE Xplore, ACM Digital Library, Wiley Online Library, and added Springer to our list of resources for this phase. This approach, more targeted than our initial broader search, allowed us to delve deeper into the subject matter. By consistently applying these specific keywords across these databases, we were able to effectively filter and identify scholarly articles and literature reviews that directly addressed our research interest in student-centered LAD, ensuring a focused and relevant collection of academic resources for our study.

When we first used the ACM Digital Library's advanced search tools with our chosen keywords, we got a wide range of 2,409 results. We first carefully examined the titles to ensure that they were pertinent to our area of study to narrow this down to the most pertinent articles. We looked more closely at the abstracts of the titles that seemed relevant so we could judge their applicability more fully. This meticulous process

enabled us to narrow our selection to four publications that were directly aligned with our research objectives.

The final phase aimed to locate papers directly related to LAD for students, particularly those incorporating surveys. Our searches in ACM and Springer databases involved the keywords "Learning", "Analytics", "Dashboard", "Students", and "Survey." This effort resulted in the selection of 1 paper from ACM and 2 papers from Springer that harmonized with our research focus. In addition, we conducted searches on Google Scholar, identifying and selecting 3 pertinent papers.

Throughout each phase, we diligently reviewed and summarized the identified papers, extracting key insights that would serve as valuable resources to inform our research and address our specific research questions.

3 Results

3.1 Previous literature review on LA and LAD

This section is subdivided into two subsections: one focused on previous literature reviews related to LA, and the other focused on reviews related to LAD.

Previous literature review on LA

From our search, we identified 4 papers that specifically relate to literature review on LA. Each paper provides unique insights into various aspects of LA, including its methodologies, applications, and the challenges it faces in educational contexts.

In their systematic literature review, Scheinman et al. [2] conduct an in-depth examination of 48 empirical studies focusing on learning analytics dashboards. Their methodology involves categorizing studies based on their impact on learning outcomes and user experience, thus offering a broad yet detailed perspective on the current state of learning dashboard research. Key findings highlight the critical role of actionable information, self-regulation features, and aesthetic design in enhancing the effectiveness of Learning Analytics (LA) tools. Notably, the review identifies a significant gap in the literature: a need for more empirical evidence on how specific dashboard functionalities directly contribute to improved educational outcomes. By addressing this, Scheinman et al. [2] provide a comprehensive overview that not only outlines essential design principles for LA tools but also sets a direction for future research aimed at validating the practical impact of these principles on learning and engagement.

Matcha et al. [1] critically explore the integration of self-regulated learning (SRL) theories in Learning Analytics (LA) tools. Their systematic review identifies a notable gap: many LA dashboards lack a strong theoretical foundation in SRL, affecting their potential to support learner autonomy effectively. The study emphasizes the need for LA designs to incorporate SRL principles more fully, suggesting future research should

focus on creating LA tools that align closely with SRL strategies to enhance learning outcomes.

Pan et al. [4] delve into the broader dimensions of Learning Analytics (LA), emphasizing its role in enhancing feedback mechanisms and support structures within educational settings. Their work specifically addresses the operational aspects of LA, showcasing how it can be harnessed to deliver personalized, timely feedback to learners and identify critical areas needing intervention. Through a detailed examination of various LA implementations, Pan et al. reveal the transformative potential of LA in fostering a more responsive and tailored educational experience. The study underscores the importance of integrating LA tools into learning activities to improve student engagement and outcomes. However, it also calls attention to the need for further research on optimizing LA's feedback delivery to maximize its effectiveness and ensure it meets diverse learner needs.

Dourado et al. [5] offer a crucial examination of Learning Analytics (LA) by situating it within the evolving educational landscape. Their work synthesizes prior research on LA, with a particular focus on visual learning analytics, to shed light on its integration and application in modern educational contexts. By reviewing the development and use of visual analytics in education, Dourado et al. [5] provide insights into how these tools can enhance learning and teaching processes. Their analysis highlights the growing importance of visual data representation in making complex data accessible and actionable for educators and learners alike. Despite the comprehensive overview, the paper calls for a deeper exploration of the pedagogical implications of visual learning analytics and its effectiveness in improving educational outcomes, pointing out an area ripe for future research.

In summary, these papers collectively paint a detailed and nuanced picture of the LA field. They highlight the evolving nature of LA, its theoretical and practical aspects, and the continuous need for research that is both theoretically grounded and practically applicable in educational settings. This comprehensive overview underscores the dynamic and multifaceted nature of LA research, offering valuable insights for future explorations in the field.

Previous Literature Review on LAD

In this section, we focus exclusively on literature reviews related to LAD. A total of 6 papers were included in this section, each providing unique perspectives and insights into the field of LAD.

These scholarly works collectively offer a deep dive into the world of LADs, illustrating their crucial role in enhancing the educational experience. They shed light on the necessity for continuous innovation, theoretically informed design, and rigorous evaluation in the realm of LADs to ensure they effectively contribute to educational advancements. Each study, with its unique focus and findings, contributes to a layered

understanding of LADs, encouraging a trajectory of research that is both innovative and grounded in educational theory.

In their systematic review, Bodily et al. [15] embark on an in-depth exploration of student-facing learning analytics systems, employing a structured classification methodology to evaluate these systems' functionalities and design in relation to student success. Through their analytical lens, they meticulously categorize and assess how various features of learning analytics systems either facilitate or impede student autonomy, with a strong emphasis on the critical roles of personalized feedback and user-centric design in promoting effective learning environments. Despite revealing the potential benefits of these systems, Bodily et al. notably highlights a significant gap in the existing literature: a dearth of empirical studies that directly correlate specific features of learning analytics systems with measurable improvements in student achievement. This gap underscores an urgent call for future research to adopt evidence-based methodologies in the development and evaluation of student-centered Learning Analytics Dashboards (LADs), aiming to substantiate their impact on educational outcomes more concretely.

Valle et al. [7] conduct a systematic review focusing on the interdisciplinary applications and evolution of Learning Analytics Dashboards (LADs) from 2010 to 2016. Through a meticulous analysis, they chart the growth of LADs across different educational contexts, pinpointing significant advancements and trends in areas such as data visualization techniques, the alignment of educational goals with LAD functionalities, and the empowerment of students through control over their learning data. This detailed examination reveals the expansive utility of LADs while concurrently underscoring critical areas where further enhancements are required. Key among their findings is the observation that despite the progress, there remains a substantial need for research aimed at refining LADs to better support instructional goals. Valle et al. [7] advocate for the development of more sophisticated LAD features that can adapt to diverse educational strategies and learner needs, highlighting this as a pivotal direction for future LAD research.

Afghani et al. [13] examine the effects of social comparison in Learning Analytics Dashboards (LADs) on students' emotions and motivation. Their qualitative study highlights how varying comparison groups affect engagement and performance, suggesting that social comparison features must be thoughtfully integrated into LADs. The findings indicate a significant impact but also point to the need for further research to determine the most beneficial comparison settings for enhancing student motivation without causing negative effects.

Joseph-Richard et al. [20] explore the impact of involving students as lead designers of Learning Analytics Dashboards (LADs) through a case study. This approach highlights the benefits of aligning LAD design with students' needs, showing that participatory design enhances LAD relevance and effectiveness. The study emphasizes

the gap in incorporating student feedback into LAD development, advocating for collaborative design to better meet learners' goals and improve engagement.

Jaishankar et al. [19] detail the creation and assessment of the TELA dashboard, using a design science research strategy to enhance online learning engagement and performance. Their process, from literature review to student evaluations, demonstrates TELA's positive impact on motivation, engagement, and academic outcomes. This work contributes a practical perspective to LAD studies, underscoring the effectiveness of customized analytics tools in educational settings.

The study by Ley et al. [8], presents a comprehensive literature review exploring the integration of intelligent learning systems with teaching practices. The paper emphasizes how model-based learning analytics can be transparent and beneficial to teachers in their decision-making processes. It underscores the potential of these technologies to enhance teacher performance and contribute to more effective instruction, focusing on the synergy between technology and teacher cognition in educational settings. This research is instrumental in understanding the evolving role of learning analytics in supporting and augmenting teaching methodologies.

These papers collectively advance the understanding of LADs, advocating for a user-centered approach that incorporates the students' voice in the design process, ensuring that LADs are not only informative but also empower learners to take charge of their educational journey. The recurring theme across the literature is the critical role of LADs in supporting self-regulated learning and providing educators and learners with the tools necessary for a data-informed educational experience.

3.2 Papers on learning analytics dashboard for students

Table provides a comprehensive overview of research papers focusing on LADs designed for students. Encompassing a total of 11 papers, this compilation offers a detailed exploration of the features and functionalities found in these student-centric LADs. These features range from real-time feedback on learning performance to personalized recommendations, interactive data visualization, and user-centered design principles. These LADs aim to empower students in various ways, such as supporting self-regulated learning, providing actionable information, enhancing engagement, and promoting better academic outcomes. The table captures the key insights from each paper, shedding light on the innovative approaches taken to harness the potential of LADs for student success in educational settings.

Table 1. Summary of Key Features in Learning Analytics Dashboards for Students

Reference	Features Found in LADs for Students (Detailed Summary)
Bodily et al. [3]	Highlights visualizations for easy data interpretation; Feedback mechanisms; Personalized recommendations; Alerts and notifications; User-friendly interface; Goal setting; and Performance tracking.
Roberts et al. [17]	Personalization; Interactivity; Analysis of student behaviors includes tracking engagement, resource utilization, submission patterns, and interaction frequencies; Historical perspective; Alerts and notifications; Performance metrics like grades, test scores, course completion rates, participation, and time spent on coursework; Peer and class comparisons.
Lim et al. [12]	Investigation of frames of reference in LADs and their effect on student sense-making; Assessment of how dashboard design influences student engagement and interpretation; Historical perspective; Importance of dashboard alignment with student cognitive processes for effective learning; Support for self-regulation through tailored presentation of LAD information; Enhanced self-regulation observed through tailored LAD presentations, highlighting the importance of design alignment with student cognitive processes.
Kia et al. [6]	Actionable information on academic progress; Support for self-regulated learning; Effective data visualizations; User-centered design; Utilizes learning analytics techniques for data analysis such as predictive modeling, data mining, and statistical analysis.
Wang et al. [9]	Visualization of students' learning behavior; Personalized feedback and recommendations; Tracking students' progress, setting goals, and monitoring achievements.
Haynes et al. [16]	Grade distribution; Student activity; Course activity views; The Procrastination and reflection views analyze and visualize task timing and prompt self-evaluation to mitigate procrastination; Social interaction insights track and visualize student participation in forums, peer reviews, and group work within the learning platform.
Love et al. [10]	Customizable interface; Progress tracking and real-time feedback; Data on engagement and performance; Goal setting and tracking; Clear and easy-to-understand visualizations; Collaboration features such as peer comparison tools, communication platforms, group progress tracking, and shared goal-setting functionalities; User-friendly interface.
Teasley et al. [11]	Assignment Planning view, Resource Accessed view, Course Performance view; Gathering user feedback and recommendations for future LAD development.
Duan et al. [18]	Actionable information to change learning behavior; User-friendly interface; Access to study resources; Visual representations of academic progress; Real-time progress updates provide current statuses on assignments and overall course achievements.
Peraic et al. [21]	Visualizations of performance, system activities, and success probability; Viewing course performance and progress; Sending and receiving alert messages; The LAD aimed to improve students' self-awareness, identify areas for improvement, and enhance their learning outcomes.
Divjak et al. [14]	Short-term planning and organization of learning activities; Customizing LAD functionalities such as personalizing interface themes, selecting preferred data metrics, and setting individualized alerts for milestones; Predictions of student's course completion, enrollment, and track of study; Notifications on personally set deadlines and reminders; Creating and monitoring individual plans for completing course and study activities.

4 Discussion

LADs have emerged as pivotal tools in the educational landscape. This literature review, centering on LADs tailored for students in higher education, meticulously analyzed 21 pertinent studies. Our examination of these studies revolved around a set

of research questions aimed at unraveling the impact of LADs on student learning outcomes, the theoretical underpinnings of their design, and their potential for enhancing the learning experience. The review highlighted key LAD features and functionalities, such as personalized feedback, data visualization, goal-setting mechanisms, user-friendliness, and collaboration support, which empower students on their educational journey. It also underscored challenges like information overload and the need for clear pedagogical approaches. Our study addressed the following research questions:

RQ:1: What key features and functionalities were identified in a learning analytics dashboard for students to improve their learning outcomes?
In the realm of LADs for students, a wealth of research has shed light on the key features and functionalities that significantly contribute to enhancing students' learning outcomes. These findings have emerged from a variety of studies conducted by different authors over the years. Matcha et al. [1] and Bodily et al. [3] have underscored the paramount importance of personalized feedback and recommendations in LADs. Real-time feedback empowers students to evaluate their own progress and performance, enabling them to make informed decisions to improve their learning outcomes. Additionally, data visualization, as emphasized by Schwendimann et al. [2] and Bodily et al. [3], emerges as a consistent theme. These visual representations, including charts and graphs, offer students a clear and concise view of their performance and learning progress, making data more accessible.

The literature also places great significance on the ability of LADs to support students in setting and tracking their goals. This proactive approach to learning is vital, as highlighted by Bodily et al. [3] and Love et al. [10]. Moreover, the user-friendliness of LADs, as advocated by Bodily et al. [3] and Jayashanka et al. [19], is paramount, ensuring that these dashboards are visually appealing and interactive, thereby enabling students to explore data when necessary. Integration with other educational technologies, an essential aspect for a seamless learning experience, is brought to the forefront by Bodily et al. [3] and Ley et al. [8].

Furthermore, accessibility across multiple devices, as noted by Bodily et al. [3] and Pan et al. [4], is crucial, as it allows students to access data and receive feedback at their convenience. Collaboration, as emphasized by Love et al. [10] and Valle et al. [7], is another crucial element. Fostering peer interaction and a supportive learning community through collaboration features within LADs is instrumental in improving learning outcomes.

In summary, the amalgamation of these features and functionalities empowers students to seize control of their learning, enhance their self-regulated learning skills, and ultimately, improve their learning outcomes. The collaborative efforts of various authors have illuminated the path to developing effective LAD that cater to the diverse needs and preferences of students in today's educational landscape.

RQ-2: Among the features identified in the literature, which ones are related to self-regulated learning?

In our pursuit of comprehending the features that are associated with self-regulated learning within the context of learning analytics dashboards, the existing literature offers valuable insights. Matcha et al. [1] and Valle et al. [7] underscore the critical nature of incorporating features that facilitate self-reflection, self-assessment, and formative assessment to bolster the process of self-regulation. Meanwhile, Kia et al. [6] places a spotlight on the significance of presenting visual representations of data necessary for metacognitive and self-regulated learning competencies. Love et al. [10] emphasizes the pivotal role of interactive visualizations, timely feedback, and active student participation in the design phase as means to stimulate goal setting, reflection, and planning. These findings, in conjunction with the insights from various other scholarly sources, collectively enrich our understanding of which specific attributes are linked to fostering self-regulated learning within learning analytics dashboards.

RQ-3: Do theoretical studies in the literature demonstrate any positive outcomes in terms of improving student behavior and learning outcomes?
In the systematic exploration of empirical studies on learning analytics dashboards, the literature offers varying insights into the impact of theoretical studies on student behavior and learning outcomes. For instance, Matcha et al. [1] and Schwendimann et al. [2] suggest that while theoretical studies emphasize the potential for positive effects, concrete evidence of improved student behavior and learning outcomes remains elusive. On the other hand, Bodily et al. [3] highlights instances of positive outcomes, such as increased course enrollment and improved predictive capabilities. Pan et al. [4] cite several theoretical studies pointing to positive impacts on student behavior and learning outcomes, although specifics are not provided. Kia et al. [6] mentions studies like "The Power of Feedback" and "How am I Doing?" as examples of positive outcomes. Ley et al. [8] presents mixed results, with roughly 40% of reported benefits unsupported. Wang et al. [9] references studies by Rakoczy et al. and Sedrakyan et al. as potential sources of positive outcomes. Love et al. [10] and Teasley et al. [11] discuss theoretical studies indicating that learning analytics dashboards can improve student behavior and learning outcomes. Lim et al. [12] suggests that theoretical studies exist, Aghaei et al. [13] emphasizes the positive impact of Learning Analytics Dashboards on motivation, performance, and engagement. Divjak et al. [14] acknowledges theoretical studies demonstrating positive outcomes while underscoring contextual variations. However, the review by Bodily et al. [3] indicates the need for further research to establish concrete evidence of positive outcomes, calling for more experimental investigations. These diverse perspectives collectively underscore the complexity and variability of the relationship between theoretical studies in the literature and their impact on student behavior and learning outcomes.

5 Conclusion And Future Works

In this literature review, we have explored the dynamic landscape of Learning Analytics Dashboards (LADs) designed for students in higher education. Our comprehensive analysis of 21 relevant studies has revealed the pivotal role of LADs in enhancing the

learning experience and supporting students' self-regulated learning. These dashboards have emerged as potent tools that provide students with personalized feedback, data visualization, and goal-setting mechanisms, allowing them to monitor their progress and make informed decisions about their educational journey. Additionally, features like user-friendliness, accessibility across devices, integration with other educational technologies, and support for collaboration have been identified as essential components of effective LADs.

However, our review also highlights challenges and areas that warrant further exploration. As we delve into the design and implementation of LADs that support metacognitive and self-regulated learning skills, we must address issues such as information overload, clear pedagogical approaches, and ensuring that these dashboards align with students' needs and preferences. The involvement of students in the design process, as advocated by some studies, will be crucial to ensuring that LADs are truly user-centric and capable of improving students' self-regulation and motivation.

To build upon the insights gained from this literature review, our future work will revolve around conducting a survey to gather feedback from students on the key features and functionalities of Learning Analytics Dashboards. This survey will serve as a crucial step in customizing and developing an effective LAD that meets the specific needs and preferences of students. By actively involving students in the design process, we aim to create a dashboard that not only empowers them but also enhances their self-regulated learning skills, including goal setting, planning, monitoring, and reflection.

The feedback obtained from the survey will guide the modifications and improvements to the LAD, ensuring that it aligns with the evolving needs of students in higher education. We plan to focus on making the dashboard more user-friendly, visually appealing, and interactive. Furthermore, we will explore strategies to support collaboration among students and foster a sense of community within the learning environment.

In summary, our future work is dedicated to bridging the gap between the theoretical framework of LADs and the practical needs and preferences of students. By actively involving students in the design process, we aim to create a more effective and user-centric LAD that can truly transform the educational experience, improving learning outcomes and enhancing the self-regulation and motivation of students in higher education.

Our literature review on Learning Analytics Dashboards (LADs) acknowledges limitations including a limited scope of reviewed studies, rapid technological advancements, and varied methodologies, which may affect the generalizability of our findings. Moreover, the actual impact of student involvement in LAD design requires further investigation. These constraints underscore areas for future research to refine and expand the understanding and effectiveness of LADs in education.

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