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Research Article

Investigating Longitudinal Effects of Adaptive Digital Learning Ecosystems on Self Regulated Learning and Academic Persistence

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Abstract: This study investigates the long-term impact of adaptive digital learning ecosystems on students' self-regulated learning (SRL) behaviors and academic persistence. Adaptive learning systems personalize the learning experience by adjusting content and feedback to meet individual students' needs, preferences, and performance. These systems enhance engagement, motivation, and learning outcomes through real-time adjustments and continuous feedback. The research aims to explore how adaptive learning systems influence SRL and academic persistence in university courses over time. Using a longitudinal quantitative design, the study tracks SRL behaviors and academic persistence at multiple points during the semester. Results show significant improvements in SRL behaviors such as goal setting, planning, self-monitoring, and reflection among students engaged with adaptive learning environments. These students exhibited greater autonomy, improved metacognitive awareness, and higher motivation. Additionally, students in adaptive systems demonstrated greater academic persistence, as indicated by more time spent on tasks, higher assignment completion rates, and sustained engagement. The findings suggest that adaptive learning platforms promote SRL and academic persistence by offering personalized, responsive learning experiences. Unlike static, non-adaptive environments, adaptive systems provide dynamic support, enhancing students' ability to regulate their learning and remain engaged despite challenges. The study concludes that adaptive learning systems are vital for long-term academic success, though further research is needed to assess the sustainability of these effects in various educational settings and among diverse student populations.

Keywords: Academic Persistence; Adaptive Learning; Educational Technology; Longitudinal Study; Self Regulated Learning

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1. Introduction

Adaptive digital learning ecosystems have become a transformative element in contemporary education by providing personalized learning experiences tailored to individual students' needs, preferences, and performance. These ecosystems leverage advanced technologies, including artificial intelligence (AI) and biometric feedback, to modify content difficulty, pacing, and learning pathways in real time (Alruwaili et al., 2025; Li et al., 2023). The significance of these adaptive learning systems lies in their ability to enhance learning effectiveness, engagement, and accessibility, thus supporting diverse learning styles and improving academic outcomes (Deng & Chen, 2025; Rojas & Chiappe, 2024). By personalizing the learning experience, adaptive systems can foster students' motivation, self regulation, and academic success.

A key feature of adaptive learning ecosystems is their ability to customize learning experiences for individual students. These systems continuously collect data on students' interactions, preferences, and performance to adjust content delivery in ways that meet each learner's specific needs (T. Li et al., 2023). This dynamic personalization supports self regulated learning (SRL), which allows students to monitor and control their learning processes. Moreover, adaptive systems provide real time feedback, which enhances students' engagement, helping them stay motivated and improving their overall learning experience (J. Li et al., 2018; Natriello & Chae, 2017). The integration of biometric data, such as heart rate and eye tracking, further strengthens the adaptability of the learning environment by providing insights into students' emotional and cognitive states (Dixit & Pathak, 2023; Otaboyeva et al., 2025).

Despite the documented short term benefits of adaptive learning systems, such as improved academic performance and heightened engagement, their long term effects on self regulated learning (SRL) and academic persistence remain underexplored (J. Li et al., 2018; She et al., 2023). SRL is an essential factor in academic success, as it involves a student's ability to manage their cognitive, motivational, and emotional states during learning. This skill is crucial not only for academic achievement but also for lifelong learning (Deng & Chen, 2025; T. Li et al., 2023). While adaptive learning systems have been shown to support immediate learning outcomes, there is a significant gap in understanding their sustained impact on students' SRL over extended periods.

In addition to SRL, academic persistence, which refers to the ability to continue learning despite challenges, is another crucial aspect of student success. Research suggests that adaptive learning environments can foster emotional resilience and motivation, both of which are essential for academic persistence (Alruwaili et al., 2025; Nakaya et al., 2025). However, the long term effects of these environments on academic persistence remain insufficiently studied. While initial studies show promising results, more research is needed to determine how adaptive learning ecosystems impact students' ability to persist academically over time, particularly in the face of challenges.

There is a need for longitudinal studies to explore the long term effects of adaptive learning systems on SRL and academic persistence. Furthermore, understanding the mechanisms through which these systems influence learning behaviors, such as the role of academic motivation and self management, is essential (Deng & Chen, 2025; Otaboyeva et al., 2025). Future research should also examine the effects of adaptive learning across various cultural and institutional contexts to gain a more comprehensive understanding of its benefits. By addressing these gaps, we can better understand how adaptive digital learning ecosystems can contribute to sustained academic success and lifelong learning.

The primary goal of this study is to investigate the longitudinal impact of adaptive digital learning ecosystems on self regulated learning (SRL) behaviors and academic persistence. Adaptive learning environments leverage technology to personalize educational content and feedback according to individual learners' needs, preferences, and performance. These personalized systems have the potential to enhance student engagement and foster academic persistence, making them a key focus for educational research. While adaptive learning technologies are widely recognized for their ability to support short term academic performance, there remains a gap in understanding their long term effects on SRL and academic persistence (Oppmann et al., 2025; Yaseen et al., 2025).

Understanding how adaptive digital learning systems influence SRL behaviors and academic persistence is crucial for several reasons. Firstly, adaptive learning technologies have been shown to significantly improve student engagement by offering tailored learning experiences. For instance, adaptive e learning platforms have been associated with increased participation in online discussions, assignment submissions, and frequent use of learning management systems (Rani & Thirunirai Senthil, 2024). These platforms also boost engagement during real time assessments, such as adaptive quiz platforms that adjust the difficulty of questions based on student responses (Ramadhan et al., 2025). By maintaining engagement, adaptive learning environments support students in developing critical SRL strategies, which are essential for long term academic success.

Self regulated learning (SRL) plays a pivotal role in academic success, particularly in digital learning contexts. SRL involves the ability to monitor and control cognitive, metacognitive, motivational, and emotional processes during learning. Research has demonstrated that adaptive learning technologies can enhance SRL by offering real time feedback and personalized learning paths that cater to individual learning needs (Colling et al., 2025; Lin et al., 2025). Furthermore, SRL behaviors such as self monitoring and self

assessment have been identified as significant predictors of academic performance. As students engage in self regulated practices, they are better equipped to manage challenges, which enhances their persistence in academic endeavors (Bernacki et al., 2025; Otaboyeva et al., 2025).

Academic persistence is another crucial factor in determining student success, as it refers to the ability to continue with academic tasks despite difficulties or setbacks. Adaptive learning environments can positively impact academic persistence by promoting sustained engagement and reducing negative learning behaviors. For example, biometric adaptive learning systems, which monitor physiological indicators such as heart rate, have been found to increase study time and reduce late submissions, indicating that students are developing more self regulated learning habits (Otaboyeva et al., 2025; Yaseen et al., 2025). Additionally, digital skill training programs that focus on SRL have been linked to improved academic retention rates and higher grade point averages, especially among first generation college students (Bruna et al., 2025).

The practical implications of this study are significant, particularly for educators and institutions looking to enhance student engagement and persistence through adaptive learning technologies. Personalized learning approaches have the potential to improve academic outcomes and student retention by providing tailored learning experiences that cater to individual needs (Bernacki et al., 2025). Moreover, the insights derived from this study can inform targeted interventions designed to support SRL behaviors, especially for students who face challenges with traditional learning methods. By integrating adaptive learning technologies into educational curricula, institutions can foster a more engaging and supportive learning environment that promotes both short and long term academic success (Ramadhan et al., 2025; Tal, 2025).

2. Literature Review

Self Regulated Learning (SRL)

Self regulated learning (SRL) is a critical component of academic success, particularly in digital learning environments. It refers to the processes through which learners take control of their own learning by setting goals, monitoring their progress, and adjusting their strategies as necessary (Winne, 2017). Various theoretical models have been developed to understand SRL, each offering unique insights into how learners engage with their learning process.

Zimmerman's Three Phase Model is one of the foundational frameworks for understanding SRL. This model divides SRL into three phases: forethought, performance, and self reflection. The forethought phase involves setting goals and planning; the performance phase is where learners apply strategies to achieve their goals; and the self reflection phase includes evaluating outcomes and adjusting strategies (Cleary et al., 2020). This cyclical nature of SRL emphasizes the ongoing process of goal setting, strategy application, and reflection that is essential for academic achievement.

Sociocognitive and sociocultural models of SRL expand upon this by focusing on the interaction between cognitive, motivational, and behavioral strategies within learning environments. These models emphasize the role of feedback, social interaction, and the environment in shaping SRL behaviors. They argue that learning is not just an internal process but also a socially mediated one, influenced by interactions with others, such as teachers and peers, and by environmental factors (Edisherashvili et al., 2022). Winne and Hadwin's Four Phase Model further refines this understanding by highlighting the recursive and dynamic nature of SRL, which involves phases like task definition, goal setting, strategy implementation, and adaptation, all of which are constantly revisited and refined as learning progresses (Winne, 2017).

Key strategies for effective SRL include metacognitive skills, motivational strategies, and behavioral strategies. Metacognitive skills involve setting goals, planning, and evaluating progress, which are essential for effective self regulation. Motivational strategies, such as maintaining intrinsic and extrinsic goal orientation and fostering self efficacy, are crucial for sustaining engagement and persistence in learning (Rajmane et al., 2025). Behavioral strategies, including time management, seeking help, and structuring the learning environment, are also integral to managing the learning process effectively (Mahmoudi-Dehaki & Nasr-Esfahani, 2025).

Adaptive Learning Ecosystems

Adaptive learning ecosystems play a crucial role in fostering SRL by personalizing the learning experience based on real time data analysis. These systems continuously assess

learners' progress and adapt the content delivery accordingly, providing immediate feedback that helps students stay engaged and motivated (Afini Normadhi et al., 2019). The personalized nature of adaptive systems ensures that students receive learning materials tailored to their needs, which can enhance their engagement and promote deeper learning.

An adaptive learning system typically consists of several components, including a learner model, domain model, instructional model, and adaptive engine. The learner model tracks individual students' progress and preferences, while the domain model ensures that the content aligns with educational goals. The instructional model dictates the teaching strategies, and the adaptive engine adjusts the learning path based on students' responses and interactions (Bekaulova et al., 2025). Technologies such as e-learning, m-learning, and gamification further enhance the adaptiveness of these systems by incorporating game based elements to increase motivation and engagement (Stalmach et al., 2023).

The role of adaptive learning ecosystems in personalized learning is multifaceted. These systems not only support equity by addressing educational disparities but also promote engagement by creating individualized learning pathways that cater to students' interests and learning styles. Personalized learning pathways foster autonomy, enabling students to take control of their learning while developing essential SRL behaviors (Yaseen et al., 2025). Furthermore, the integration of adaptive learning technologies helps foster lifelong learning skills by continuously supporting students as they progress through their educational journeys (Stalmach et al., 2025).

Impact of Digital Learning on Self Regulation

Digital learning environments, particularly those that incorporate adaptive learning technologies, have been shown to significantly enhance students' SRL and learning autonomy. Studies indicate that digital tools, such as personalized learning paths, real time feedback, and progress tracking, can improve students' ability to regulate their learning (Rajmane et al., 2025). These tools provide students with the autonomy to make decisions about their learning, which is crucial for the development of self regulation.

Empirical evidence supports the positive impact of digital learning technologies on SRL. Students who engage with adaptive learning platforms exhibit higher levels of self regulation, problem solving, and adaptability (Stalmach et al., 2023). These technologies not only improve learning outcomes but also enhance students' ability to manage their own learning, making them more resilient in the face of academic challenges. In particular, students with special educational needs benefit from digital learning environments that promote self regulation, leading to improved academic outcomes and better emotion regulation (Stalmach et al., 2025).

However, there are challenges associated with digital learning environments. Fatigue and cyberloafing, or off task behavior, are common issues in online learning contexts that can hinder student engagement and learning satisfaction (Agrawal & Krishna, 2025). These issues highlight the importance of creating supportive digital environments that foster self regulation. Self regulation can help mitigate the negative effects of fatigue and cyberloafing, emphasizing the need for adaptive learning systems that provide ongoing support and feedback (Edisherashvili et al., 2022). Effective interventions, such as scaffolding, real time feedback, and adaptive strategies, are essential to support SRL in digital environments and ensure that students remain engaged and motivated (Rajmane et al., 2025).

Academic Persistence and Its Relationship with Learning Systems

Academic persistence is a crucial determinant of student success, reflecting a learner's ability to continue pursuing academic goals despite challenges. Learning environments, particularly adaptive systems, play a significant role in fostering persistence. Adaptive learning systems, which tailor educational content to individual needs, offer personalized feedback and support that helps maintain student engagement over time. Research has shown that these systems enhance engagement by providing continuous assessment and adjusting content delivery in real time, which fosters a sense of ownership and control over the learning process (Fu et al., 2025). In turn, this personalized approach has been linked to increased academic persistence, as students feel more connected and supported in their learning journey.

In addition to personalization, the interaction between students and their learning environment significantly influences persistence. Student, student instructor, and student content interactions have been identified as key factors affecting academic persistence. For instance, academic emotions such as enjoyment, anxiety, and boredom mediate the relationship between these interactions and persistence. Environments that support autonomy and foster positive emotions such as enjoyment and passion encourage students to persevere in their academic efforts (Wang et al., 2021; Yu et al., 2020). Autonomy supportive environments, which provide learners with more control over their learning

processes, have been shown to promote intrinsic motivation and increase persistence, ultimately contributing to better academic outcomes (Wang et al., 2021).

Previous Longitudinal Studies on Digital Learning

Longitudinal studies on the long term effects of adaptive learning systems have provided valuable insights into their impact on academic persistence and overall learning outcomes. One of the notable findings from studies on computer assisted instruction (CAI) is the enduring impact of adaptive learning systems like the Waterford Early Learning (WEL) program. Research has demonstrated that students who participated in WEL outperformed their peers even one to two years after completing the program, indicating that adaptive learning environments can have lasting effects on academic persistence and performance (Shamir et al., 2022). The dosage effect, where longer exposure to adaptive systems correlates with better outcomes, further emphasizes the importance of sustained engagement with these systems for long term academic success.

Similarly, studies on biometric adaptive learning environments have shown that prolonged exposure to such systems leads to improved academic routines, better stress management, and enhanced knowledge retention. These systems not only support academic persistence by providing personalized learning paths and real time feedback but also help students manage their emotions and stress, which are crucial factors for sustained engagement (Otaboyeva et al., 2025). The long term benefits of these environments highlight their potential to foster self regulated learning (SRL) behaviors and improve academic persistence over extended periods, making them valuable tools for promoting sustained academic success in diverse learning contexts.

3. Research Method

This study employs a longitudinal quantitative design to examine the long term effects of adaptive learning systems on self regulated learning (SRL) behaviors and academic persistence. University students enrolled in courses using adaptive learning platforms will be tracked over time, with data collected on SRL through standardized surveys, academic performance via grades and persistence indicators, and engagement through system usage analytics. SRL will be measured using tools like the Motivated Strategies for Learning Questionnaire (MSLQ), while academic records will provide insight into long term success. System usage data, such as time spent on the platform and interaction frequency, will measure engagement. Statistical methods, including repeated measures ANOVA and regression analysis, will analyze changes in SRL and their impact on academic persistence. This approach will reveal how adaptive learning systems influence long term academic behaviors, persistence, and overall learning outcomes, providing insights into their sustained impact.

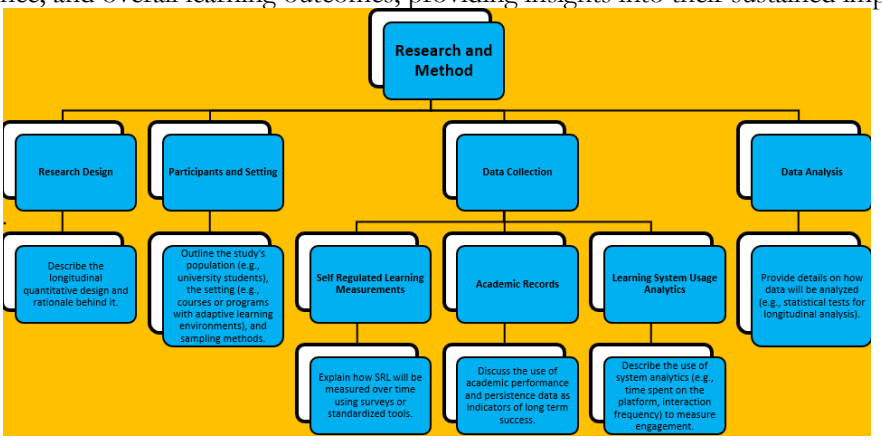

Figure 1. Research Methodology Flowchart Structure

Research Design

This study adopts a longitudinal quantitative research design to examine the long term effects of adaptive learning systems on self regulated learning (SRL) behaviors and academic persistence. A longitudinal approach allows the tracking of SRL and persistence over time, providing insights into how adaptive learning systems influence students' academic journeys. By collecting data at multiple points throughout the academic term, the study can identify trends and variations in SRL and academic persistence, contributing valuable findings on the lasting impact of these learning environments.

Participants and Setting

The participants in this study will be university students who are enrolled in courses that utilize adaptive learning systems, particularly those designed to personalize educational content and feedback based on individual student needs. The study will focus on students who have been exposed to adaptive learning environments for at least one semester, ensuring sufficient data is available to track changes over time. The setting will be a university, where adaptive learning systems are integrated into various programs, including subjects such as mathematics, science, and language arts. A stratified sampling method will be employed to ensure a diverse sample, representing different academic disciplines and year levels, providing a broad view of the effects of adaptive learning across various student groups.

Data Collection

Self Regulated Learning Measurements

To assess SRL over time, the study will use standardized tools like the Motivated Strategies for Learning Questionnaire (MSLQ) and the Self Regulated Learning Interview Schedule (SRLIS). These tools are well established in educational research for measuring key SRL behaviors such as goal setting, planning, monitoring, and self reflection. Participants will complete these surveys at several time points during the semester, allowing for the analysis of changes in SRL as they interact with the adaptive learning platform. This will provide insights into how SRL evolves in response to adaptive learning environments.

Academic Records

Academic performance data, including grades, test scores, and persistence indicators (such as course completion rates and retention), will be obtained from institutional records. These data will serve as quantitative measures of long term academic success. By tracking students' academic progress over multiple semesters, the study aims to explore how engagement with adaptive learning systems influences academic persistence and achievement.

Learning System Usage Analytics

Engagement with the adaptive learning platform will be tracked using system analytics, which record data on the amount of time spent on the platform, frequency of logins, and interactions with learning materials such as quizzes, assignments, and discussion forums. This data will be automatically collected from the platform and analyzed to measure student engagement. The analysis of system usage data, along with SRL and academic performance data, will help assess how engagement correlates with learning outcomes and persistence in academic activities.

Data Analysis

The data collected from SRL measurements, academic records, and system usage analytics will be analyzed using appropriate statistical methods for longitudinal data. Repeated measures analysis of variance (ANOVA) will be used to assess changes in SRL behaviors over time, while regression analysis will help identify the impact of engagement and SRL on academic persistence and performance. Correlation analysis will also be conducted to explore the relationships between system usage, SRL behaviors, and academic persistence. These analyses will provide a comprehensive understanding of how adaptive learning environments contribute to sustained engagement and academic success over time.

4. Results and Discussion

The study found that adaptive learning systems significantly enhance students' self regulated learning (SRL) behaviors and academic persistence. Over time, students in adaptive environments demonstrated improvements in goal setting, planning, and self reflection, facilitated by real time feedback and personalized learning paths. These systems also promoted higher engagement, as students showed greater persistence in completing tasks and assignments, especially during challenging periods. The findings align with existing literature, indicating that adaptive learning platforms foster greater autonomy, motivation, and metacognitive awareness, which are crucial for academic success. However, further research is needed to explore the specific mechanisms, such as emotional regulation, that mediate the effects of adaptive learning on persistence and SRL. Additionally, long term studies tracking students beyond the study period could provide insights into the sustainability of these benefits and their impact on academic performance over time.

Results

The study found significant improvements in self regulated learning (SRL) behaviors among students who participated in adaptive learning environments. Over time, students demonstrated enhanced abilities in key SRL areas, such as goal setting, planning, monitoring, and self reflection. These improvements were facilitated by the real time feedback and personalized learning paths offered by the adaptive systems, which allowed students to track their progress and adjust their learning strategies accordingly. The continuous adjustments

made by the adaptive platforms helped students maintain their focus and motivation, leading to an increase in their overall SRL capabilities throughout the study period.

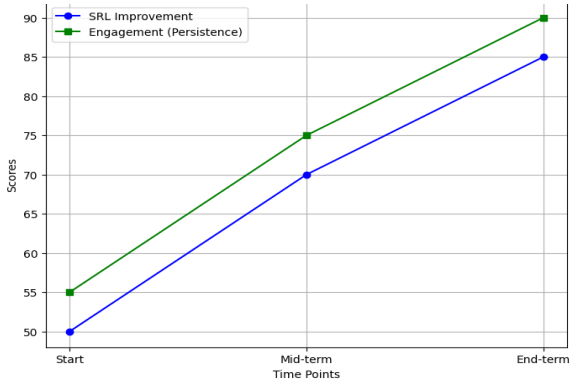

Figure 2. SRL Improvements and Engagement Over Time

The graph above illustrates the progress of self regulated learning (SRL) and academic persistence (engagement) over time in adaptive learning environments. The blue line represents SRL improvements, which show a steady increase from the start to the end of the semester, highlighting how students' abilities to plan, monitor, and self reflect on their learning enhanced as they engaged with the adaptive learning system. The green line reflects academic persistence, also showing an upward trend, indicating that students' engagement in learning activities grew stronger over time, with higher participation and completion rates. These trends suggest that the adaptive learning system not only improved students' SRL strategies but also positively influenced their academic persistence. The data demonstrates the potential of adaptive learning environments to foster long term academic success by promoting both self regulation and sustained engagement, which are essential for overcoming academic challenges and achieving educational goals.

In terms of academic persistence, students engaged with adaptive learning systems exhibited higher levels of engagement and completion rates. These students spent more time interacting with the learning platforms, participated in more online activities, and showed better completion rates for assignments and tasks. This enhanced engagement was particularly evident during challenging periods in the semester, where students reported feeling more supported by the personalized nature of the learning environment. The adaptive systems' ability to reduce stress and provide tailored support helped foster sustained academic effort, contributing to higher academic persistence and completion rates.

Discussion

The results of this study align with existing literature that highlights the positive impact of adaptive learning systems on self regulated learning. Previous studies have demonstrated that adaptive learning technologies, by offering personalized learning experiences and continuous feedback, can enhance SRL behaviors. The improvements observed in students' SRL behaviors, including better goal setting and self reflection, are consistent with findings suggesting that personalized learning environments can foster greater autonomy and metacognitive awareness. This study further supports the idea that adaptive systems help students develop essential skills for academic success, as they enable learners to regulate their own learning processes more effectively over time.

In terms of academic persistence, the findings reinforce the notion that adaptive learning environments contribute to long term engagement and motivation. Previous research has shown that personalized learning platforms can enhance student motivation, which is a key predictor of academic persistence. In this study, students in adaptive environments demonstrated greater persistence in completing tasks and staying engaged throughout the semester. This can be attributed to the way adaptive systems reduce barriers to learning, such as stress or confusion, by providing real time feedback and support tailored to each student's needs. As students feel more confident and supported in their learning journey, they are more likely to persist in their academic endeavors.

Despite the positive results, there are areas that warrant further exploration. One limitation of this study is the need for a deeper understanding of the mechanisms through which adaptive learning systems influence persistence and SRL. While the real time feedback and personalized learning paths were instrumental in promoting engagement, further research is needed to explore how specific elements, such as emotional regulation or intrinsic motivation, mediate these effects. Additionally, the long term sustainability of these improvements in SRL and academic persistence remains an open question. Future studies should consider tracking students beyond the study period to assess whether the benefits of

adaptive learning systems persist over time and continue to influence academic success. Furthermore, exploring the impact of adaptive learning environments in different cultural and educational contexts could provide valuable insights into how these systems can be optimized for diverse student populations.

5. Comparison

The outcomes observed in adaptive learning systems differ significantly from those seen in static, non adaptive digital environments. Adaptive systems, by design, tailor the learning experience to each student's individual needs, preferences, and performance. This customization allows for real time adjustments in the content delivery, pacing, and difficulty, which has been shown to enhance student engagement, motivation, and self regulated learning (SRL) behaviors. In contrast, static, non adaptive systems deliver a uniform learning experience to all students, often providing the same content and feedback regardless of individual progress or challenges. As a result, students in non adaptive environments may struggle to stay engaged or may not receive the support they need to effectively monitor and regulate their learning behaviors. This lack of personalization can lead to lower levels of SRL and academic persistence, particularly among students who face difficulties in traditional learning environments.

In non adaptive systems, students often experience less interaction with the content and may lack the timely feedback required to adjust their learning strategies. This can lead to disengagement and a lack of motivation to continue with the coursework, especially when students encounter obstacles that are not addressed by the system. On the other hand, adaptive systems actively address these barriers by providing individualized feedback and adjusting learning paths, making it more likely that students will persist and succeed in their academic endeavors.

One of the key advantages of adaptive learning systems is their ability to deliver superior long term outcomes in both SRL and academic persistence compared to non adaptive systems. The longitudinal nature of adaptive systems allows students to develop essential self regulation strategies over time, as they continuously receive personalized feedback and adjust their learning approaches. This process of ongoing adaptation fosters stronger SRL behaviors, such as goal setting, self monitoring, and reflection, which are critical for academic success. Students engaged in adaptive learning systems report higher levels of confidence in their ability to manage their learning, which leads to greater persistence in completing coursework and overcoming challenges.

Moreover, the long term benefits of adaptive systems extend beyond the immediate academic term. Studies have shown that students who engage with adaptive learning platforms exhibit better retention rates and sustained academic performance even after they have completed the course. This continued success can be attributed to the development of lasting SRL skills and the cultivation of academic persistence through personalized learning experiences. In contrast, non adaptive systems, which do not offer the same level of personalized support or feedback, often fail to foster the same degree of self regulation or long term engagement, leading to lower persistence and poorer academic outcomes in the long run.

6. Conclusion

This study highlights the significant positive impact of adaptive learning systems on students' self regulated learning (SRL) behaviors and academic persistence. The findings show that students who engaged with adaptive learning environments exhibited notable improvements in SRL strategies, including goal setting, planning, and self monitoring. These improvements were facilitated by the personalized nature of the adaptive systems, which provided real time feedback and tailored learning paths. Furthermore, the study demonstrated that adaptive systems contribute to academic persistence, with students spending more time on tasks, completing assignments at higher rates, and maintaining engagement throughout the academic term. Overall, the adaptive learning environments fostered both stronger SRL and greater academic persistence compared to traditional, non adaptive systems.

The findings of this study suggest that educational institutions can leverage adaptive digital learning ecosystems to significantly enhance student engagement and persistence. By implementing adaptive systems, institutions can provide personalized learning experiences that cater to individual student needs, thus improving learning outcomes and fostering self regulation. These systems can also be particularly beneficial for students who struggle with traditional learning methods, as they offer continuous support and real time feedback. Educators and institutions should consider integrating adaptive learning technologies into their curricula to support students in developing essential SRL skills and to promote sustained academic engagement. Additionally, by personalizing the learning experience, adaptive

systems can contribute to higher retention rates, better academic performance, and overall student success.

While this study provides valuable insights into the benefits of adaptive learning systems, there are some limitations to consider. One limitation is the scope of the study, which focused on a specific population of university students enrolled in adaptive learning programs. Future research could explore how adaptive systems affect diverse student populations, including those from different educational levels, cultural backgrounds, or special educational needs. Another limitation is the short term nature of the study, which focused on changes over the course of one semester. Longitudinal studies that track students' SRL and academic persistence beyond the immediate academic term would provide deeper insights into the sustained impact of adaptive learning systems. Furthermore, future research could examine the integration of adaptive systems with other educational technologies, such as collaborative learning tools or gamification, to explore how these combined approaches enhance student engagement, SRL, and academic persistence in various learning contexts.

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