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The Impact of AI-Driven Real-Time Feedback Systems on Students'Self-Regulated Learning and Academic Persistence in Secondary Schools in Nigeria

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Abstract

Self-regulated learning (SRL) is essential for secondary school students to achieve academic success and lifelong learning competencies, particularly in contexts requiring greater learner autonomy. This expository article examines the potential of Artificial Intelligence (AI)-driven real-time feedback systems to support SRL processes planning (forethought), monitoring (performance/control), and reflection within Nigerian secondary education. Grounded in Zimmerman's cyclical SRL model and Bandura's Social Cognitive Theory, the paper conceptualises AI tools (e.g., intelligent tutoring systems, learning analytics dashboards, chatbots, and adaptive feedback platforms) as environmental scaffolds that enhance metacognition, motivation, self-efficacy, and behavioural regulation. Drawing on global and emerging empirical evidence, AI facilitates personalised, timely feedback that targets process- and self-regulation levels, promoting deeper engagement, strategy adaptation, and persistence. However, implementation in Nigeria faces significant challenges, including infrastructural deficits (e.g., unreliable internet and power), limited digital literacy, teacher readiness, unequal access, and ethical concerns such as data privacy, bias, and over-reliance, leading to diminished learner agency. The conceptual framework positions AI as a mediator of SRL dimensions while moderated by contextual and ethical factors. Empirical reviews indicate positive associations between AI-supported feedback and improved SRL behaviours, though longitudinal studies in developing contexts remain scarce. The article underscores the need for balanced, human-centred integration to foster genuine autonomy rather than dependency. It concludes with practical recommendations for policymakers, educators, and developers to advance equitable AI adoption in resource-constrained secondary settings.

Keywords: AI-driven feedback, self-regulated learning, academic persistence, generative AI, secondary education, Nigeria.

Introduction

The shift from primary to secondary education is a crucial period in the educational journey of any student as responsibility for thinking and acting becomes imperative to unlock their potential and ensure their success (Latipah et al., 2021). These skills like planning learning activities, working with peers, and expressing ideas through verbal and nonverbal means are very important for students' academic performance at this stage (Tadesse et al., 2022). These skills are considered to be basic to the process of self-regulated learning (SRL), which includes setting goals, evaluating and monitoring progress and results.

In the context of secondary education, where students are expected to learn without much direct instruction (Zimmerman, 2000), the development of SRL skills, especially planning, monitoring, and reflection, is becoming an important factor. Empirical evidence consistently shows that SRL improves problem-solving skills, academic performance, intrinsic motivation and task interest (Cleary & Zimmerman, 2004; Perry & Vandekamp, 2000; Pintrich, 2000; Zimmerman, 2002). In addition to academic achievement, SRL also leads to other developmental gains such as positive future orientation, effective social behaviour management, and the development of lifelong learning skills (Bandura, 2006). These skills are also important for future issues like the rising competitiveness of the labour market (Latipah et al., 2021; Muwonge et al., 2020; Nguyen & Zarra-Nezhad, 2023). Although it is important, many learners have difficulty regulating their learning and underutilizing SRL strategies (Greene & Azevedo, 2010; Jansen et al., 2020; Winne & Baker, 2013). This underlines the need of structured and scalable support systems to help improve SRL in secondary school. A promising solution is using artificial intelligence (AI) in learning environments.

AI has great potential to overcome these challenges by offering timely, task-specific, and individualised feedback to support self-directed learning. AI systems can provide real-time scaffolding for SRL through displaying personalized prompts based on learners' engagement and performance data, such as planning, monitoring, and reflection (Cavalcanti et al., 2021; Lim et al., 2023). AI feedback can go beyond traditional feedback for correctness, aiming for more profound cognitive and metacognitive processes. Moreover, they are scalable, adaptable, and can offer continuous support without any need for constant human interaction (Mejeh, Sarbach, & Hascher, 2024).

When developing AI to support SRL, two main functions are normally considered: (1) evaluation and analysis of learners' SRL behaviours in the online learning environment and (2) provision of scaffolding to facilitate the SRL process (Roll & Winne, 2015). Various AI-powered tools such as planning assistants (Somasundaram et al., 2020), intelligent tutoring systems and pedagogical agents (Goel & Polepeddi, 2016) have been developed to facilitate SRL. There is evidence that these technologies can enhance students' performance, engagement, and interest, especially in STEAM areas (Salas-Pilco et al., 2022). For example, adaptive learning systems and learning analytics platforms can offer personalized learning paths and real-time feedback, fostering deeper understanding and retention of knowledge.

Feedback in general is an important factor in learning knowledge and improving skills. Time and place of delivery boost the effectiveness and efficiency of learning. Quality feedback can help students to regulate

themselves, enhance their learning and help to persist with their learning (Hattie & Timperley, 2007). In the traditional classroom setting, however, providing timely and personalized feedback, especially in the context of open-ended or constructed response tasks, remains a challenge.

New developments in automatic scoring for written work, such as natural language processing and machine learning, are striving to alleviate this constraint and provide instant feedback on written student responses (Dzikovska et al., 2013; Liu et al., 2016). Feedback is used for cognitive, metacognitive and motivational purposes in digital learning environments (Panadero & Lipnevich, 2022). AI can now be used to provide continuous and real-time feedback that allows learners to pinpoint misconceptions, control learning, and maintain motivation (Cavalcanti et al., 2021; Wisniewski et al., 2020. The effectiveness of such feedback, however, is not guaranteed if it is not designed, timed and aligned with the needs of the learner (Shute, 2008). These advantages are enhanced in the computer-based setting, where feedback can be tailored and made available to many at the same time (Azevedo & Bernard, 1995).

Conversational agents, like chatbots, represent a valuable opportunity for AI to support SRL among innovations. Chatbots are virtual learning companions that can support learning in a personalised, on-demand way. They can help with the important aspects of SRL, such as setting goals, self-monitoring and reflection, by interacting with learners in real time. SRL strategies involve consciously-engaged actions to plan, monitor, and assess learning (Thompson, 2016). Although classical note-taking, rehearsal and mnemonic devices are still useful, they don't necessarily have the flexibility and customization that digital technology can provide.

This incorporation of AI into SRL practice, thus, is a major paradigm change from the conventional approach. It provides personalised learning experiences, improves conceptual understanding, helps build problem-solving skills and boosts learner engagement. AI systems can help to overcome these and other chronic issues in education, like low engagement and high attrition rates, by integrating smart feedback mechanisms into learning environments. In the present context of education systems which are full of knowledge and where teachers are becoming facilitators, the learner should be prepared to manage his/her own learning process. Therefore, self-control is crucial for learning and staying in school, particularly in online and hybrid learning settings.

However, the implementation of SRL is difficult, especially in the context where rote learning is dominant, learning depends on the teacher, and metacognitive instruction is not emphasized. The situation is particularly notable in secondary schools in Nigeria where the teacher-centred methods of instruction limit learners' autonomy and strategic thinking. In these settings, AI can optimize SRL by giving feedback in real time, encouraging reflection, aiding goal setting, and mimicking tutor–learner interactions. AI tools can be used to analyse students' learning behaviours and suggest personalized strategies, which can help students to manage their learning more efficiently. Additionally, new technologies like AI and 5G can help to improve access to quality education by providing personalised learning opportunities, irrespective of geographical or socioeconomic factors.

Although there has been increasing research on SRLs and feedback, there are still a few significant gaps. These constructs have been studied separately, and few studies have explored how AI-based in situ feedback can concurrently impact SRL processes in integrated L2 learning contexts. Also, there is not enough evidence of the impact of such feedback in the ongoing process of planning, monitoring and reflection. Furthermore, while the use of AI in education is growing around the world, particularly in secondary schools in developing countries such as Nigeria, it is still under-researched. This gap is especially important in the light of the difficulties involved in getting personalized feedback, inconsistent quality of teaching and learning, and infrastructural limitations.

Given this context, a holistic and context-aware analysis of AI-based real-time feedback systems, which can facilitate SRL and lead to improved academic success in persistence, is needed. In this regard, this paper takes an expository approach to examine the effect of such systems on students' planning, monitoring and reflection of their learning in Nigerian secondary schools. It also deals with mechanisms, empirical evidence, context-specific applications and contexts, and practical suggestions on how it can be effectively implemented.

OBJECTIVES OF THE STUDY

The purpose of this expository article is to explore the potential of implementing AI-driven real-time feedback systems in supporting students' SRL and persistence in learning in the context of Nigerian secondary schools. In particular, the study aims to accomplish the following:

1.To examine how AI-driven real-time feedback systems can scaffold the core phases of SRL planning (forethought), monitoring (performance/control), and reflection among secondary school students in Nigeria.

2.To explore the mechanisms through which AI-powered tools, such as intelligent tutoring systems, learning analytics dashboards, adaptive learning platforms, and conversational agents (chatbots), enhance students' metacognition, motivation, self-efficacy, and behavioural regulation.

3.To analyse the influence of AI-supported real-time feedback on students' academic persistence, engagement, strategy adaptation, and overall learning outcomes in Nigerian secondary education.

4.To identify the major contextual challenges and opportunities for implementing AI-driven feedback systems in Nigerian secondary schools, including infrastructural limitations, digital literacy gaps, teacher readiness, equitable access, and ethical concerns such as data privacy and algorithmic bias.

5.To develop a conceptual framework that positions AI tools as mediators of SRL processes while accounting for key moderating factors specific to the Nigerian secondary education environment.

6.To offer practical, context-sensitive recommendations for policymakers, school administrators, teachers, and technology developers on the effective, equitable, and human-centred integration of AI-driven real-time feedback systems that promote genuine learner autonomy rather than over-dependence.

Through these goals, the investigation aims to fill the gap between what has been achieved with AI for learning at the global level and the context of learning in secondary schools in Nigeria, which will help to create more autonomous, motivated and persistent learners in resource-limited environments.

CONCEPTUAL FRAMEWORK

The conceptual model for this research demonstrates the interplay between the use of AI tools and the three central aspects of SRL: planning, monitoring, and reflection in the context of Nigerian higher education. The framework is based on the SRL theory by Barry J Zimmerman and the Social Cognitive Theory by Albert Bandura, which both view learning as an active and social process and depend upon the interplay of cognitive, behavioural and environmental factors.

AI tools serve as essential environmental supports that boost the three cyclical phases of SRL, as illustrated in Figure 1. For instance, intelligent tutoring systems can be used to support the planning phase through guiding the learner to set goals and choose learning strategies; learning analytics dashboards and chatbots can help monitor the learner's progress, and feedback systems and learning analytics tools can enhance reflection by offering actionable insights for the learner to consider and improve future learning strategies. These mechanisms enable AI tools to realize the main characteristics of SRL, which scaffold learners' metacognitive processes and encourage active learning engagement.

In addition, consistent with Bandura's Social Cognitive Theory, learners' motivation and self-efficacy are also affected by these AI-powered interventions, which offer timely feedback, demonstrate effective learning strategies and diminish uncertainty while completing a task. This interaction between the learning environment and the learner helps to maintain motivation, make intelligent decisions, and boost interest in learning activities. Therefore, AI's role in SRL processes can indicate better L2 self-direction results, including self-efficacy in L2 learning, autonomous problem solving and L2 persistence.

But factors like infrastructural capacity, teachers' readiness and moral issues influence the effectiveness of this relationship. In the higher education setting in Nigeria, ongoing issues like low teacher-student interaction, poor digital infrastructure, and unequal access to digital resources can limit the effective utilization of AI tools (Petrie, Aladin, Ranjan, Javangwe, Tuominen, Gilliland & Leponiemi, 2020). Additionally, ethical considerations and pedagogical alignment should be addressed in the use of AI in education to ensure responsible use, data protection, and meaningful learning experiences (Nguyen, Ngo, Hong, Dang & Nguyen,2022; Jin, Im, Yoo, Roll, & Seo, 2023; Hooda, Rana, Dahiya, Rizwan, & Hossain, 2022).

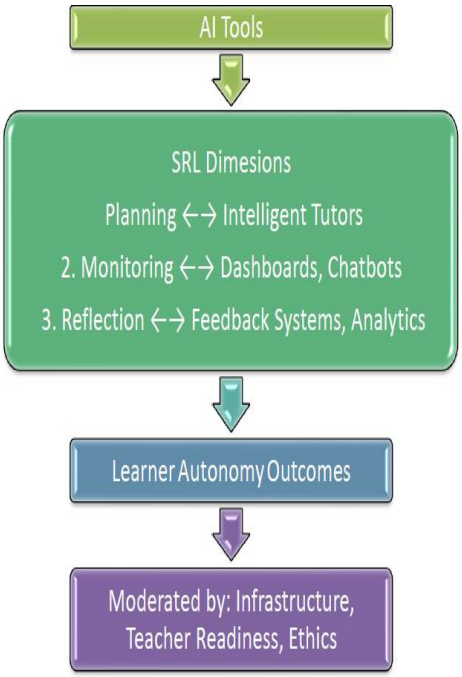

Figure 1: AI-SRL-LR Model
Source: Omoyajowo, Bambi, Femi, & Ayeni (2025)

Thus, this framework sees AI tools as enablers and mediators of SRL, focusing on their ability to support learners in planning, monitoring, and reflecting on their learning, and the need to consider contextual and ethical factors for successful educational outcomes. The framework shown in Figure 1, thus, offers a structured lens through which to explore the potential of AI-supported interventions in supporting SRL and academic achievement in Nigerian universities.

THEORETICAL FRAMEWORK

The study is based on two theories: the SRL model by Barry J. Zimmerman and Social Cognitive Theory (SCT) by Albert Bandura, which explains the SRL of the learners' cognition, motivation, and behavior in technology-enhanced learning environments in a comprehensive way.

According to Zimmerman (2000, 2002), the SRL model is a cyclical process including forethought, performance and self-reflection in which learners actively set goals, monitor their performance and evaluate the learning outcomes. Based on previous conceptualizations (Zimmerman, 1986), self-regulated learners are those who actively choose strategies, monitor their own performance, and reflect on the results to enhance future learning. In secondary and tertiary education, the growing need to learn independently puts high cognitive and metacognitive demands. An imbalance occurs when learners don't have the necessary regulatory (planning, monitoring, and reflective evaluation) skills and leads to disengagement, low academic persistence, and poor learning outcomes. Moreover, SRL is not a natural process but a developmental one that needs to be developed in a systematic way with the aid of targeted support or intervention, especially in situations where SRL is essential.

Therefore, SRL can be seen not only as a study skill, but also as a very complex and active process which involves a continuous cognitive effort, strategic action and motivational control. Bandura's Social Cognitive Theory helps further explain these processes as it focuses on the interaction between aspects of the person (self-efficacy and beliefs), aspects of behavior (strategies used and persistence), and aspects of the environment (feedback and instruction) (Bandura, 1986, 2006). The idea of reciprocal determinism and of observational learning (when individuals learn knowledge and skills by observing the behaviors of others) is central to SCT. An important principle of the theory is that learners' perceptions of their own ability greatly influence their desire to persist, their level of effort and participation when faced with academic difficulties.

In technology-mediated learning environments, real-time feedback is becoming a key environmental resource that can support the requirements of SRL, with AI becoming a vital component in this process. These systems

provide immediate, individualized, and adaptive feedback and thus can assist students with goal setting, progress monitoring and performance reflection. Further, with AI systems like intelligent tutoring systems, feedback systems that adapt to student performance, and virtual tutors, students can observe effective problem-solving techniques, simulate certain features of social interaction, and receive motivational scaffolding, consistent with Bandura's focus on observational learning and external support. These feedback "mechanisms" not only support SRL processes, but can also boost self-efficacy by giving timely evidence of progress and alleviate uncertainty while working with the task, especially when resources are scarce in the educational environment.

Based on this, this study takes an integrated SRL-SCT view to investigate the role of AI-based real-time feedback as an external SRL support that not only enhances L2 learners' SRL ability to plan, monitor, and reflect but also influences their motivation, self-efficacy and persistence. In this view, AI-supported feedback acts as a cognitive scaffolding and an environmental tool to facilitate successful self-regulation, learner autonomy and continued engagement in learning in the secondary school setting.

EMPIRICAL REVIEW

Self-regulated learning (SRL) is defined as the degree to which learners actively control their learning process by setting goals, choosing strategies, monitoring themselves and reflecting on their learning. It is generally understood as an iterative process that includes the cognitive, metacognitive, motivational and behavioural aspects. In the current context of education, especially when it comes to technology, SRL has become an important aspect of students' success.

The use of AI in supporting SRL processes has been pointed out in recent empirical studies. For example, Chardonnens (2025) highlights the importance of incorporating metacognitive strategies in technology-mediated learning environments, suggesting that AI-driven tools can support SRL by offering immediate feedback, suggesting learning strategies, and visualising learning. This notion can be supported by the quantitative study of Ghulam, Zafar, and Asha (2026), which investigated the effects of AI-focused personalised learning on student motivation and SRL in HE. Their results showed that there was a significant positive correlation between AI personalised learning, students' motivation and SRL, indicating that the use of adaptive AI systems had a positive effect on the motivation of learners, their autonomy in learning and their strategic learning behaviours. The study also revealed some hurdles including digital literacy, ethics, and equitable use of AI, suggesting that the advantages need to be carefully managed and implemented.

In the same way, Faraz, Bushra, Zarina, and Asia (2025) studied the correlation between AI educational technologies, SRL and academic performance through quantitative research. They found a strong positive correlation between the use of AI and SRL and that SRL is a significant predictor of academic achievement in their regression analysis. The findings also showed that the higher the level of interaction with the AI tools, the better the learners' planning, monitoring, and reflective skills were. However, an issue raised was the over-reliance on the AI system, which needs to be addressed, and learners should learn to be autonomous and self-paced in order to prevent over-reliance. These results further support the synergistic role of AI and SRL in supporting lifelong learning and better academic outcomes.

On a wider scale, Lan and Zhou (2025) conducted a systematic review based on PRISMA protocols to provide a synthesis of empirical research on AI in SRL in higher education. Their results show that AI can be used to effectively assist with the forethought, performance and reflection stages of SRL. They also identify a key tension between human-centred and AI-centred regulation that can impact the nature and effectiveness of SRL processes. The review highlights the need for a balance between technological support and maintaining the agency and self-efficacy of the learner and also recommends that further research needs to be conducted to optimise this balance. Another piece of empirical evidence is providing feedback based on AI in improving SRL. In terms of SRL behaviours, students in the AI-generated feedback group showed significantly better and more positive results than students in the other two groups, such as initiating tasks earlier, using extra learning resources more often, and maintaining more regular study habits (Rakhmetov et al., 2025). Their results indicate that even a simple AI-driven feedback system can be used to facilitate SRL for all students in digital learning environments to enhance their learning engagement.

Jin et al. (2023) analyzed the students' perceptions of AI applications in supporting SRL in the context of online learning. The findings showed that learners' perception of AI tools was positive in terms of cognitive, metacognitive and behavioural aspects of SRL, yet it was negative in terms of motivational aspects of SRL. The study also identified essential pedagogical and psychological issues (learner identity, activeness, positionality) that need to be taken into account in the design of an AI-supported learning system. To complement these

findings, Huang, Stephens and Brown (2025) did a systematic review on technology-enhanced feedback systems and found feedback to be a key element of SRL and learning. Their review highlights that AI and other technologies can boost feedback processes with real-time, multimodal and multi-source feedback. Moreover, these systems provide self-assessment and a better interpretation and use of feedback. Yet the authors highlight the importance of paying more attention to the students' interaction with and use of the feedback in practice.

Notably, evidence in the use of AI and SRL in Nigeria is beginning to surface but is very encouraging. Initial research in the Nigerian higher education context indicated that technology-enhanced learning tools are becoming more prevalent as a result of the demand for personalised learning, limited instructional resources and large class sizes. Although there are still no large-scale empirical studies, there are sufficient pieces of evidence that AI-supported feedback and learning systems can enhance students' self-regulation, engagement, and learning results. Yet, contextual factors like infrastructural gaps, digital literacy and technology access/usage inequalities are key factors that could impact the effectiveness and scalability of these innovations.

The overall results of this empirical literature indicate that there is a positive correlation between the use of AI, feedback and the development of SRL. The potential of AI technologies for improving the autonomy, engagement and performance of learners is great, especially when using personalised learning and adaptive feedback. However, there are ongoing issues about equality, ethical use, digital competence and dependency, which are issues that need to be taken seriously and implemented in a context-appropriate manner. These findings indicate that, although AI can be a valuable tool for supporting SRL, there is a need to strike a balance between AI's technological capabilities and the cultivation of students' autonomous learning skills.

ARTIFICIAL INTELLIGENCE AND SELF-REGULATED LEARNING

SRL has great value for students because they can plan their study activities, monitor themselves and adjust their learning process for improvement. There are numerous researchers and scholars who believe that students who are self-regulated are high-achieving students and that their effectiveness is a product of self-set goals, regulated time-use, and ongoing self-assessment. Self-regulation strategies have proved to be very effective, but they do not always emerge naturally in all learners, so the possibility of support with AI has been investigated. Adaptive learning tools, educational chatbots, and intelligent tutoring systems are AI applications designed to help students through various SRL phases. These systems assess student performance, pinpoint areas for improvement, and propose solutions as students learn. For example, if students are struggling with a difficult subject, AI can provide them with tips and guidance to keep them engaged and motivated. Evidence also reveals that AI is most commonly used in the planning phase and in monitoring, but less frequently in the goal-setting and reflection phases, which are both integral to autonomous learning (Laak & Aru, 2024).

One of the best contributions of AI to SRL is the capacity to offer personalized support. Personalization and the learning paths that accompany it keep students motivated since the content is relevant to them. For example, 'Adaptive Learning Systems' engage students to think and reflect on their errors. They enable students to be active learners and enhance their self-management and monitoring (Holmes & Littlejohn, 2024). Likewise, adoption of AI-powered chatbots and intelligent tutoring systems can help in sending plan reminders, encouraging active self-monitoring, and promoting self-regulation. However, literature explicitly states that there are potential risks. AI prompts that assist with self-monitoring and regulation can be potentially excessive, leading to a learned passivity. Over-reliance on AI can reduce the level of genuine self-regulation, which restricts the capacity of learners to regulate their own learning (Lee, Hwang & Chen, 2025). Using technology to interact and guide learning performance and self-regulation: Chatbot-assisted SRL. This means that AI works best when it is used as a facilitator and the student takes care of regulating learning.

AI has the capability to enhance SRL; however, several risks and challenges remain. A potential danger is that pupils may become incapable of functioning alone. As students become more reliant on automation, they might be neglecting important aspects of goal setting, planning, and reflecting by taking automated suggestions and advice that determine how to learn. Equity and access are also issues. In situations where schools and students lack resources, advanced technologies are also limited, thus disproportionately hindering the adoption of AI-based SRL tools (Billman, 2024). There are also ethical implications of using AI, such as data security, privacy, and fairness, as AI depends on sensitive student information. Researchers also point out that there is a lack of research on the sustainability of the benefits of using AI in L2 writing and whether students can apply their SRL strategies to new writing tasks (Wu et al., 2023). Such issues need to be

addressed in design and implementation that intentionally and fairly involve and leverage AI.

SELF-REGULATED LEARNING AND AI TOOLS

SRL is the ability of the learner to plan, monitor, and evaluate learning strategies, which includes cognitive and metacognitive skills. AI-driven personalized learning environments offer the possibility of active support for SRL, including features like goal-setting tools, progress tracking dashboards, and real-time prompts. These features help you reflect, adapt your strategy and manage learning better. For instance, learning analytics can alert students if they are lagging or propose alternate ways of gaining mastery over a content area, which can enhance awareness of different learning patterns. Studies show that students with AI-based systems show improvement in aspects like goal setting, time management, and strategic thinking as compared to students who are in the traditional classroom setting (Achuthan, 2025).

Several AI applications in place support SRL in various areas. Somasundaram et al. (2020) developed an AI system that suggests action plans to students and offers learning tips to them after analysing the historical institutional data and contemporary student performance while setting learning goals. A virtual human was presented by Craig and Schroeder (2017) with multiple voices, which had a positive impact on learning outcomes and cognitive load. Luckin (2017) presented a smart assessment system to recommend study materials and strategies for each student according to his or her online activities. Additional examples include Seo et al. (2021a, 2021b), who created an AI analytics tool that can give instructors analysis of students' behavioural data (e.g. clickstream, quiz attempts, log in/log out patterns, eye tracking, etc.) in the context of a specific learning (e.g. during a course week, during an exam, when rewatching a video, etc.). Woolf et al. (2010) created an AI companion, which can motivate students by providing emotional support for students who are behind schedule and suggesting goals that are realistic in terms of the student's career plans. Goel and Polepeddi (2016) developed an AI agent that can respond to students' queries, either prior to, as they engage with a course, or following course completion, based on data collected from past course offerings. Srinivasa et al. (2021) created Notelink, an application that can be used to capture images of notes and recall the corresponding instructional video on the student's device. Ross et al. (2018) designed an adaptive quiz system that utilizes AI to create personalized quizzes based on students' knowledge levels. Conati et al. (2021) stressed the need to have interpretable machine learning so that AI can help with students' self-reflection for longer.

Despite the many SRL tools available with AI, the impact of these tools in AI learning environments is yet to be determined. Seo et al. (2021a, 2021b) discovered that students have mixed feelings about the usefulness of AI applications, but feel they may be less creative if using AI. Students have voiced concerns about issues of responsibility, agency, and surveillance with AI in online learning. It is necessary to understand learners' perceptions of AI-supported SRL, therefore. These insights can lead to the development of AI systems that are able to appropriately support SRL while maintaining social and ethical boundaries in the online learning environment (Luria et al., 2020).

CONCLUSION

The purpose of this explanatory study is to highlight the transformative power of AI in real-time feedback and its implications for promoting SRL among secondary school students in Nigeria, where conventional teaching methods are not fully effective in fostering SRL and autonomy. Drawing on Zimmerman's cyclical model and Bandura's Social Cognitive Theory, the discussion illustrates how AI can support the fundamental SRL stages of planning, monitoring, and reflection through a variety of tools, including intelligent tutors, analytics dashboards, and conversational agents. These technologies offer tailored, adaptive support to address missing timely feedback, build self-efficacy through mastery experiences, and promote motivational regulation in more independent learning settings.

Research conducted around the world and now emerging in other countries reveals positive relationships between AI interventions and increased SRL, such as planning, monitoring, adjusting, reflective evaluation, engagement, and academic persistence. However, in the context of Nigerian secondary education, where issues of large class sizes, limited attention from teachers, the predominance of rote learning, and educational infrastructural gaps are present, AI can serve as a scalable solution to provide individualised guidance and mitigate disparities.

However, there are risks involved with integration. While AI's promise of personalized learning can aid independent self-regulation, over-reliance on AI can lead to a loss of such self-regulation, and disparities in access, ethical concerns (e.g., privacy, bias), and teacher preparation may reinforce rather than bridge gaps in

self-regulation. The conceptual framework highlights the importance of contextual moderators and ethical precautions in using AI as an environmental mediator, enabling it to work alongside, not replace, the human actor.

In conclusion, the use of AI for feedback in secondary schools in Nigeria shows potential as a means of fostering more independent, motivated, and effective learning. AI can help advance educational equity, resilience, and preparation for future challenges in a knowledge-driven world by thoughtfully addressing barriers and prioritizing learner-centred design.

RECOMMENDATIONS

To make the most of the use of AI in providing real-time feedback for SRL in secondary education in Nigeria, and to reduce the risk of it, the following context-specific suggestions are proposed:

1.Government and educational authorities should prioritize investments in reliable digital infrastructure (e.g., affordable internet, power backups, and device access) in secondary schools, particularly in underserved rural and peri-urban areas. Policies mandating ethical AI guidelines—aligned with frameworks like those from Nguyen et al. (2022)—should address data privacy, bias mitigation, and equitable deployment to prevent widening the digital divide.

2. Integrate mandatory training programs on AI literacy, SRL scaffolding, and hybrid human-AI pedagogy into teacher professional development. This should equip educators to interpret AI-generated insights, facilitate reflective discussions, and guide students in using tools without over-dependence, fostering complementary roles where teachers focus on motivation and socio-emotional support.

3.Developers and educators should prioritize open-source or low-cost, mobile-compatible AI tools (e.g., chatbots via SMS/WhatsApp integration) that emphasize process-oriented feedback over mere correctness. Designs must incorporate features promoting learner agency, such as optional prompts, explainable outputs, and gradual fading of scaffolds to encourage independent regulation.

4. Initiate localized pilot interventions in diverse Nigerian secondary contexts (urban/rural, public/private) to generate longitudinal evidence on AI's sustained impact on SRL and academic outcomes. Collaborate with researchers to evaluate not only performance gains but also risks like reduced creativity or dependency, informing iterative improvements.

5. Embed student and parental consent mechanisms, transparent AI usage policies, and monitoring for equity in all implementations. Promote hybrid models where AI supports SRL in resource-limited settings while preserving human interaction to build trust, self-efficacy, and transferable skills.

When implemented collectively, these may pave the way for AI as a robust facilitator of SRL to promote academic equity and help prepare Nigerian secondary school pupils for lifelong and self-directed learning.

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