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Emerging Trends in Self-Regulated Learning: A Bibliometric Analysis of MOOCs and AI-Enhanced Online Learning (2014–2024)

Yanxing Xue, Fariza Binti Khalid* and Aidah Binti Abdul Karim
The National University of Malaysia
Kuala Lumpur, Malaysia

Abstract. Low levels of student engagement remain a challenge in online learning. However, in the post-pandemic era, the rapid evolution of online education has positioned self-regulated learning (SRL) as a critical determinant of learner success, particularly within massive open online courses (MOOCs) and artificial intelligence (AI) enhanced platforms. The objectives of this study are to synthesize the existing literature, identify research gaps, and propose new directions for advancing SRL in online learning environments. This bibliometric analysis examines the current state of research on SRL in online learning environments, particularly focusing on MOOCs and AI-enhanced platforms from 2014 to 2024. Using bibliometric methods, this study analysed 42 relevant articles retrieved from major academic databases, including Web of Science, Scopus, and ScienceDirect. This review identifies a substantial increase in research interest in SRL following the COVID-19 pandemic, focusing on cognitive and metacognitive strategies, while emotional and motivational aspects remain underexplored. Research methodologies used to support SRL, such as questionnaires and observational studies, were evaluated with AI tools, demonstrating the potential to enhance goal setting, self-monitoring, and time management. However, the scalability and long-term effectiveness of these tools remain under-researched. This review also highlights key issues such as the early-stage integration of AI in SRL research. This emphasizes the need for scalable AI-driven tools and comprehensive evaluation systems to better understand and optimize the effectiveness of SRL interventions in online learning environments.

Keywords: self-regulated learning; online learning; massive open online courses; artificial intelligence

1. Introduction

Online learning often faces challenges such as low levels of student engagement in MOOCs (Wang et al., 2022). However, with rapid advancements in online

* Corresponding author: *Fariza Binti Khalid, Fariza.khalid@ukm.edu.my*

education, SRL has gained significant attention as a crucial factor for learner success, particularly in MOOCs and platforms enhanced by AI (Wang et al., 2022). This study conducted a bibliometric analysis of empirical research on SRL within the evolving landscape of online education, focusing on MOOCs and AI-enhanced learning environments. Technology has significantly transformed education, fostered innovative methods and reshaped traditional practices (Blau et al., 2020). This shift to digital learning demands that learners develop SRL skills to manage the flexibility and autonomy of their environments. Modern technologies have renewed interest in SRL, a foundational concept in educational psychology, highlighting its importance in addressing contemporary educational challenges (Blau et al., 2020).

In online learning environments, SRL is regarded as a critical factor that positively influences student success (Cho & Shen, 2013). Strategies for supporting online learners' SRL have been widely examined. Given the similarities and differences between traditional online courses and online learning, there is an urgent need for further empirical investigations of SRL in these digital environments. MOOCs, as one of the most significant aspects of online learning, have become an increasingly prominent subject of research. An analysis of research proposals submitted to the MOOC Research Initiative (MRI) indicates that SRL and social learning are among the five primary themes for future MOOC research (Gasevic et al., 2014). Advances in AI have opened new possibilities for learning science research. AI technologies facilitate the complex analyses of diverse data types, providing fresh insights into learning processes and self-regulated learning (Järvelä et al., 2020; Molenaar, 2021; Nguyen et al., 2023). The purpose of this study therefore is to analyze systematically and report on the current state of research on SRL in MOOCs and AI.

As online learning evolves with the integration of AI in the post-pandemic era, SRL has gained recognition as a critical factor influencing learner behaviour in these environments (Walter, 2024; Terras & Ramsay, 2015). However, a gap remains in the literature regarding the comprehensive analyses of SRL research, particularly from a bibliometric perspective. Existing studies often focus on specific aspects of SRL, such as cognitive and metacognitive strategies, while overlooking broader trends and gaps that bibliometric methods can reveal (Zheng et al., 2023). This study analyzes research from 2014 to 2024 to highlight the evolution of SRL research, especially as the adoption of online learning platforms has increased during and after the COVID-19 pandemic (Stracke et al., 2022). Although AI-enhanced online learning has shown potential in supporting SRL through real-time feedback, adaptive learning, and personalized goal setting, studies on its impact remain in the early stages. By expanding the scope of the analysis, this research aims to provide a more comprehensive understanding of the field and identify emerging trends and future directions. Understanding how MOOCs and AI applications contribute to autonomous learning across disciplines is essential to advancing SRL research (Järvelä et al., 2020; Cho & Shen, 2013).

2. Theoretical Background

2.1 Self-regulated learning theory

Self-regulated learning theory serves as a fundamental theoretical framework that sheds light on how learners actively monitor, control, and regulate their cognitive processes to optimize learning outcomes (Theobald, 2021; Zimmerman, 2000). Grounded in cognitive, metacognitive, and motivational principles, the SRL theory highlights the dynamic interplay between learners' cognitive strategies, motivation, and self-awareness in shaping their engagement with learning tasks and goals. Self-regulated learning theory offers valuable insights into how learners harness metacognitive processes to regulate their engagement with learning tasks (Jansen et al., 2020). Metacognitive regulation, which involves awareness and control over one's cognitive processes, is central to self-regulated learning. It enables learners to set goals, select appropriate strategies, and monitor their progress toward achieving these goals.

At its core, self-regulated learning theory posits that learners are not passive recipients of knowledge but are somewhat active agents who actively participate in their learning process (Jansen et al., 2020). According to this perspective, learners engage in a cyclical process of goal setting, planning, monitoring, and evaluating their learning activities, and adapting their strategies based on feedback and reflections to achieve desired learning outcomes. Moreover, self-regulated learning theory underscores the importance of motivational factors in driving and sustaining learners' engagement with learning tasks. Motivation, both intrinsic and extrinsic, serves as a powerful force that influences learners' willingness to engage in learning activities, persist in the face of challenges, and exert effort toward achieve their goals. The theoretical framework of learning engagement, informed by the SRL theory, seeks to elucidate the intricate dynamics between learners' cognitive processes, motivation, and self-regulation strategies. By integrating SRL perspectives with metacognitive regulation, educators can design learning environments that promote active engagement, foster metacognitive development, and enhance learning outcomes among students (Wang, 2022).

By embracing SRL theory, educators can empower students to become active participants in their learning, equipped with the metacognitive and motivational resources needed to navigate complex learning tasks and achieve academic success (Broadbent, 2017). Thus, the SRL theoretical framework offers a comprehensive perspective of the cognitive, motivational, and metacognitive foundations of learning engagement, highlighting the importance of self-regulation in fostering meaningful and enduring learning experiences. SRL is characterized by learners taking the initiative and responsibility for their educational development, which is crucial for success in self-directed learning environments, such as MOOCs and AI-enhanced online learning platforms.

2.2 Self-Regulated Learning in Online Learning

With the rapid advancement of Internet technologies, online learning has become increasingly prominent in education, especially in higher education and professional training (Kerimbayev et al., 2023). Online learning also includes

blended learning, flipped classrooms, and competency-based education, all of which present unique opportunities and challenges for SRL. For instance, blended learning environments require students to navigate between face-to-face and online modalities, demanding the development of adaptive SRL strategies that balance guidance and autonomy (Bernard et al., 2014). Similarly, flipped classrooms, which emphasize pre-class preparation and in-class problem solving, rely heavily on students' ability to self-regulate their learning before engaging in collaborative activities (O'Flaherty & Phillips, 2015). In these new learning environments, students require strong SRL skills to ensure effective learning outcomes. SRL emphasizes learners' active involvement in their learning process through goal setting, strategy selection, time management, and self-assessment (Zimmerman, 2000). Unlike in traditional classroom settings, learning environments often lack face-to-face guidance and supervision, making self-regulation even more essential for student success. Recent studies have delved into SRL's role of SRL in online learning, highlighting its impact on learning outcomes, engagement, and experience (Rahmani et al., 2024).

SRL provides a theoretical framework for online learning that supports learners in effectively managing their study process through a combination of metacognitive, motivational, and behavioural strategies (Pintrich, 2004). Given the flexibility of the online environment, SRL strategies are critical. Broadbent and Poon (2015) found that students with high levels of SRL skills outperformed those with lower levels of SRL skills in terms of academic achievement and course completion in online higher education. This underscores SRL's significance as a determinant of learning success. Research suggests that high-level SRL learners tend to monitor and evaluate their progress, adjusting as needed to adapt to the dynamic demands of online learning environments.

Several key SRL strategies play crucial roles in online learning, particularly in self-paced settings. Goal setting and planning are foundational to effective learning, helping students establish clear objectives and map realistic paths. Time and task management are especially vital in online learning, where the flexibility of study schedules requires learners to develop strong time management skills to avoid procrastination and distraction. Kizilcec et al. (2017) found that effective time management significantly improves course completion rates and helps students balance various tasks in online courses. Self-monitoring and self-assessment are also essential strategies as learners regularly reflect on their understanding, identify challenges, and adjust their approaches to maintain progress. Motivational regulation further supports students in maintaining positive learning attitudes, especially when encountering challenges. Together, these SRL strategies foster autonomy and enhance learning outcomes in online contexts.

Despite SRL's benefits, its implementation in online learning environments presents challenges. Learners' SRL abilities vary significantly, leading to disparities in learning outcomes in online learning environments. Kahu and Nelson (2018) noted that a lack of real-time support from instructors and peer interaction can create a sense of isolation among some learners, negatively impacting their academic performance. Additionally, the diverse range of

resources available in online learning can lead to cognitive overload, making it difficult for some students to remain focused on their core learning tasks. The abundance of online resources and information requires learners to utilize suitable materials selectively, which can be particularly challenging for those with weaker SRL skills (Palanci et al., 2024).

2.3 Self-Regulated Learning in MOOCs

Since 2020, research on SRL in MOOCs has intensified, highlighting the critical role of SRL in online education. The autonomous nature of MOOCs necessitates learners to manage their learning processes effectively to achieve success. Studies have shown that learners with strong SRL skills are more likely to complete MOOCs and achieve higher academic performance. For instance, Shi et al. (2024) found that students with higher self-regulation were better equipped to overcome challenges in MOOC, leading to improved problem-solving abilities and course completion rates.

Recent investigations have explored the interplay between motivational factors and SRL in MOOCs. Lee et al. (2020) examined the relationships between self-efficacy, task value, and SRL strategy use among MOOC learners. Their findings indicated that both self-efficacy and task value were positively correlated with the employment of SRL strategies, suggesting that learners who believe in their capabilities and value tasks are more likely to engage in self-regulated behaviours. This underscores the importance of fostering both confidence and the perceived relevance of course materials to enhance SRL in MOOCs.

Moreover, the COVID-19 pandemic has accelerated the adoption of online learning platforms, bringing SRL to the forefront of the educational discourse. UNESCO (2020) emphasized the necessity of supporting SRL strategies to ensure effective learning during school closures. This global shift has prompted educators and researchers to develop interventions aimed at enhancing SRL among MOOCs. For example, Jansen et al. (2020) implemented short instructional videos that focused on SRL phases, followed by reflective questions, to improve learners' self-regulation. Such initiatives highlight ongoing efforts to equip MOOC learners with the skills necessary for autonomous and effective learning.

2.4 Self-Regulated Learning in AI-Enhanced Online Learning

Since 2020, the integration of AI into educational settings has significantly influenced SRL by providing personalized and adaptive learning experiences. AI-driven systems can analyze learners' behaviour and performance in real time, offering tailored feedback and resources that align with individual learning needs. Jin et al. (2023) demonstrated that AI applications could effectively support SRL in online learning environments by measuring and augmenting learners' self-regulation capabilities.

The advent of generative AI, particularly large language models such as ChatGPT, has further transformed SRL by facilitating interactive and personalized learning experiences. Lai (2024) explored how generative AI chatbots could be integrated into SRL models, highlighting their potential to assist learners in setting goals, monitoring progress, and reflecting on outcomes. This integration enables

learners to engage in self-regulatory processes more effectively as AI chatbots can provide immediate context-specific feedback and guidance.

AI-powered educational tools have been developed to scaffold SRL by offering adaptive and informative feedback. Afzaal et al. (2023) proposed an explainable AI-based approach that provides automatic and intelligent feedback to support students' self-regulation with the aim of improving their performance in online courses. Such tools not only assist learners in planning and monitoring their learning activities but also enhance their SRL skills by making the learning process more transparent and understandable.

SRL plays a pivotal role in determining the success of learners in MOOCs as these platforms often require students to take greater responsibility for their learning than traditional educational settings (Kizilcec et al., 2017). Building on this, the integration of AI into education has significantly enhanced both the understanding and support of SRL, offering innovative solutions to address the challenges learners face in MOOCs. AI-driven tools such as intelligent tutoring systems and learning analytics enable personalized feedback, adaptive learning paths, and real-time monitoring of learners' progress, fostering the development of SRL skills (Roll & Winne, 2015). These technologies complement SRL strategies already employed in MOOCs and enhance their effectiveness by identifying students' strengths and weaknesses and prompting learners to adjust their goals and strategies accordingly.

As online learning has begun to transform in combination with AI in the post-epidemic era, SRL has recently gained attention as a crucial factor for learners in courses (Walter, 2024; Terras & Ramsay, 2015). However, there is a noticeable gap in the literature regarding the comprehensive analyses of SRL research in these contexts, particularly from a bibliometric perspective. Existing studies have primarily focused on specific aspects of SRL, such as cognitive and metacognitive strategies, while neglecting the broader trends and gaps that bibliometric analysis could reveal. By analyzing research published between 2014 and 2024, this study incorporates a wealth of recent findings, reflecting the evolution of SRL research, particularly after the COVID-19 pandemic, which significantly accelerated the adoption of online learning platforms (Stracke et al., 2022).

Unlike prior studies, which often neglect the emotional and motivational dimensions of SRL, this study emphasizes these underexplored aspects, providing a more holistic understanding of SRL. Moreover, while AI-enhanced online learning has shown potential in supporting SRL processes, such as real-time feedback, adaptive learning, and personalized goal setting, research on its long-term impact and scalability is still in its infancy. By adopting a bibliometric approach, this study systematically examined global research trends, addressing the regional imbalances and methodological limitations of existing studies. This expanded scope captures emerging trends and new research directions, offering actionable insights for educators and policymakers to design more inclusive and effective SRL strategies in MOOCs and AI-enhanced learning environments.

3. Research Questions

SRL plays a pivotal role in online education, especially in MOOCs and AI-enhanced online learning, enabling learners to manage their learning progress and sustain engagement effectively. However, the existing research has revealed several unresolved challenges. Most studies focus on specific aspects of SRL, such as strategies, but lack a comprehensive bibliometric perspective that captures global research trends. This study incorporates the literature from 2014 to 2024, including insights reflecting the rapid growth of online learning following the COVID-19 pandemic. These gaps underscore the need for a deeper understanding of SRL in online learning environments and form the basis of the following research questions:

RQ1: What is the status of studies on activities related to SRL in online learning (MOOCs and AI) published from 2014 to 2024?

RQ2: What tools and methods have been used to support SRL in MOOCs and AI-enhanced online learning environments and how effective are they?

RQ3: What are the main findings and shortcomings of the existing literature?

4. Methodology

4.1 Literature Screening

This study followed the systematic review procedures for social science research outlined by Petticrew and Roberts (2006). Systematic reviews are described as literature reviews that adhere strictly to "a set of scientific methods designed to minimize systematic error (bias), primarily by identifying, evaluating, and synthesizing all relevant studies, regardless of design, to address a specific question or set of questions" (Petticrew & Roberts, 2006). This study adopts a bibliometric approach to analyze trends, methodologies, and findings in SRL research within MOOCs and AI-enhanced online learning environments from 2014 to 2024. However, during the preliminary literature screening, it became evident that the sheer volume and diversity of publications in this domain posed significant challenges for traditional systematic reviews. Moreover, there is a need to capture macro-level trends, such as citation patterns, thematic clusters, and temporal shifts, aligned more closely with the objectives of bibliometric analysis. Bibliometric analysis was selected for its ability to handle large datasets and uncover patterns in research output, citation networks, and thematic trends, thus providing a macro-level understanding of the field (Zupic & Čater, 2015). In contrast to systematic reviews, bibliometric analysis enables the examination of large datasets through quantitative methods, revealing research trends, influential works, and collaboration networks (Zupic & Čater, 2015). This approach was deemed more suitable for achieving the goals of this study, including identifying key themes, emerging topics, and gaps in SRL research over the past decade. While systematic reviews focus on content-based synthesis, bibliometric analysis provides complementary insights by leveraging citation metrics and keyword analyses to map the research landscape. Thus, the shift to bibliometric analysis ensures methodological rigour and alignment with the study objectives. Tools such as VOSviewer and Biblioshiny were employed to visualize co-citation networks and thematic clusters, revealing research trends and gaps.

This study uses the Web of Science (WoS), Scopus, and Science Direct databases as primary data sources and collected articles from January 2014 to November 2024, using the keywords "SRL", "self-regulated learning", "Internet" and "online learning" as a criterion for screening articles. Table 1 summarizes the details of the collected papers. Since relevant research has mainly concentrated on the past decade and has surged in the past five years, this article selects data from 2014-2024 as the main research objective[†].

Table 1: Data Source and Number of Papers Collected

Database	Number of papers collected
WoS	410
Scopus	247
Science Direct	611

In addition, Figures 1 and 2 summarize trends in relevant literature in the WoS and Scopus databases from January 2014 to November 2024 and make line and bar charts.

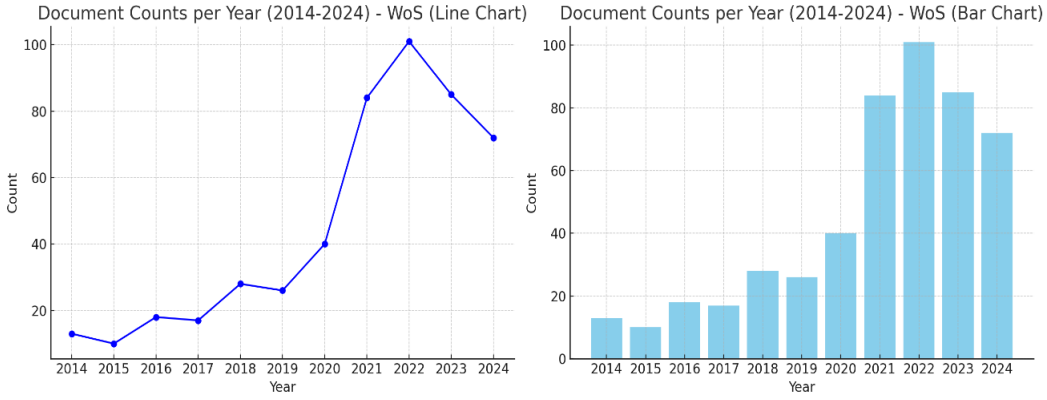

Figure 1: Documents Counts per Year (2014-2024) - WoS

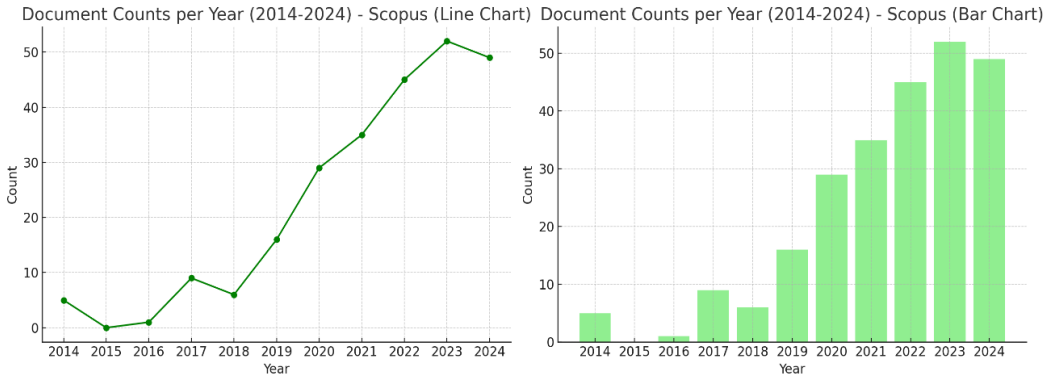

Figure 2: Documents Counts per Year (2014-2024) - Scopus

[†] Since there is no complete annual data for 2024, the data used in this article are all real-time information from WoS, Scopus and Science Direct.

From Figures 1 and 2 it can be concluded that in the WoS database, from 2014 to 2017, publications related to online learning and self-regulated learning were limited, indicating early research interest. Starting in 2018, publication numbers rose sharply, peaking at 101 in 2022, likely because of heightened interest during the COVID-19 pandemic. The numbers declined slightly in 2023 and 2024 to 85 and 72, respectively, suggesting that interest may have stabilized but remained high compared to pre-pandemic levels, highlighting the topic's lasting significance.

Similarly, the Scopus database showed low publication counts from 2014 to 2017, followed by steady growth beginning in 2018. The peak was in 2023, with 52 publications reflecting sustained interest after the pandemic. Although there was a slight decrease to 49 by 2024, the overall level remained elevated, demonstrating continued research engagement. The absence of data in 2015 may reflect a gap in indexing or research; however, the overall trend shows an increased focus, especially after the pandemic.

Both databases show a significant post-2020 rise in publications, reflecting the global shift towards digital and online education driven by the pandemic. Although growth slowed slightly after the peak years, publication counts remained higher than those of pre-2020, underscoring the topic's lasting relevance and suggesting continued interest in optimizing self-regulated learning in online environments.

4.2 Constructing a Flowchart

The following section presents a detailed literature screening process. Initially, 1,268 articles were retrieved from three databases: 410 from the WoS, 247 from Scopus, and 611 from ScienceDirect. After initial filtering, articles related to MOOCs (31 from WoS, 16 from Scopus, and 170 from ScienceDirect) and AI (14 from WoS, 2 from Scopus, and 102 from ScienceDirect) were selected, resulting in a total of 335 articles. Subsequently, review articles were excluded, including three MOOC-related and two AI-related articles from WoS, one MOOC-related article from Scopus, and 11 MOOC-related and 19 AI-related articles from ScienceDirect, leaving 299 articles. Further refinement involved removing articles without "SRL," "MOOC," or "AI" in their titles. Finally, duplicate articles were removed, resulting in 42 eligible articles for analysis.

Articles were systematically filtered to focus on the intersection of SRL, MOOCs, and AI, thus reflecting the research objectives of this study. The inclusion criteria prioritized the primary research articles that explicitly addressed these key concepts in their titles or abstracts. Additionally, the decision to exclude review articles was based on their potential overlap with other sources and lack of original empirical findings.

The iterative refinement process, involving keyword-specific filtering and duplicate removal, highlights the rigorous methodological approach adopted to minimize bias and maintain a focus on the research scope. Narrowing the initial pool of articles to 42 ensured a targeted and manageable dataset for in-depth

bibliometric analysis. This systematic approach strengthened the reliability and validity of the findings and ensured the representation of high-quality studies within the final selection. The screening process is shown in Figure 3:

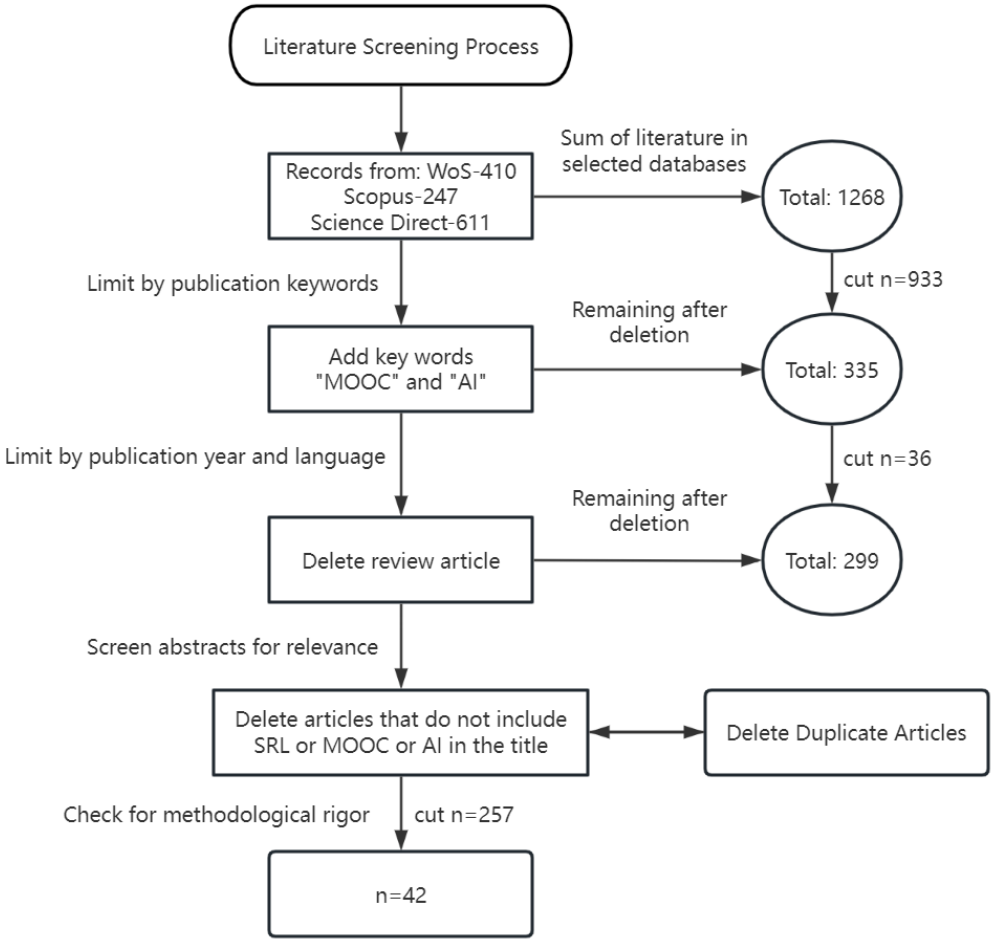

Figure 3: Literature Screening Process

5. Results

A systematic screening process was conducted to ensure the relevance and quality of the studies analyzed in this study. This involved identifying articles mentioning SRL, MOOCs, or AI in their titles, and removing duplicate entries. After refining the initial articles using rigorous inclusion and exclusion criteria, 42 high-quality studies were selected. These studies were categorized based on their research participants, as shown in Figure 4, with a focus on specific learner groups and their contexts. This categorization lays the foundation for understanding the representation and diversity within the selected studies, paving the way for a deeper analysis of SRL trends and gaps in the current research.

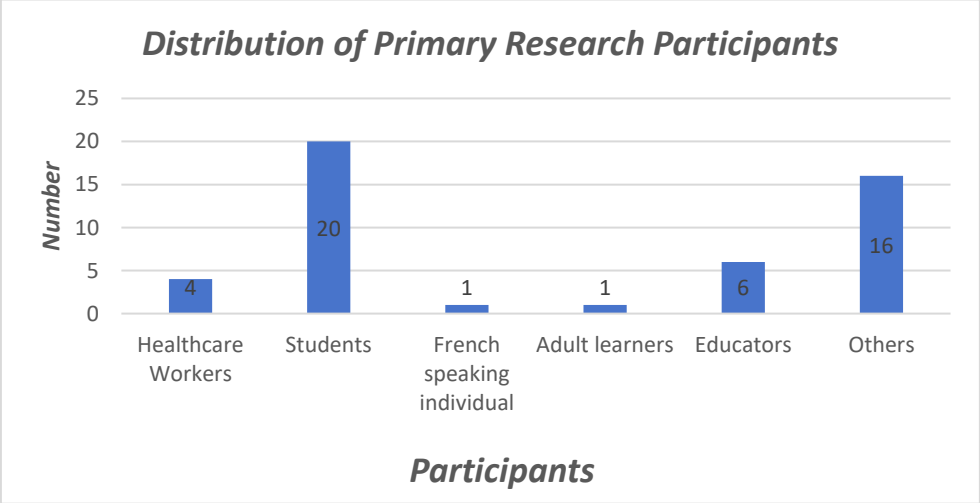

Figure 4: Distribution of Primary Research Participants

Figure 4 illustrates the distribution of primary research participants across the studies synthesized in this review. Among the 40+ articles analyzed, students (including high school- and university-level learners) were the most frequently studied, comprising 20 cases. This dominance highlights the significant focus on student populations in research, which likely reflects their central role in education-related inquiries. The second largest group, categorized as "Others," accounted for 16 cases. This category includes diverse MOOC user groups such as hobbyists in specific fields, working professionals, and other learners engaged with MOOCs, indicating the varied demographic reach of these platforms.

Educators, including teachers and other education professionals, featured in six cases, reflecting a moderate level of attention in the reviewed literature. In contrast, healthcare workers were the subjects in only four cases, suggesting a relatively limited focus on this group. Two groups of French-speaking individuals and adult learners were studied in only one case each, indicating minimal representation in the analyzed studies.

The distribution of participants underscores a predominant emphasis on students while revealing gaps in research involving adult learners, linguistically diverse populations, and specific professional groups, such as healthcare workers. Additionally, the inclusion of diverse MOOC users in the "Others" category highlights the potential of MOOCs to cater to a wide range of learners, which warrants further exploration in future research.

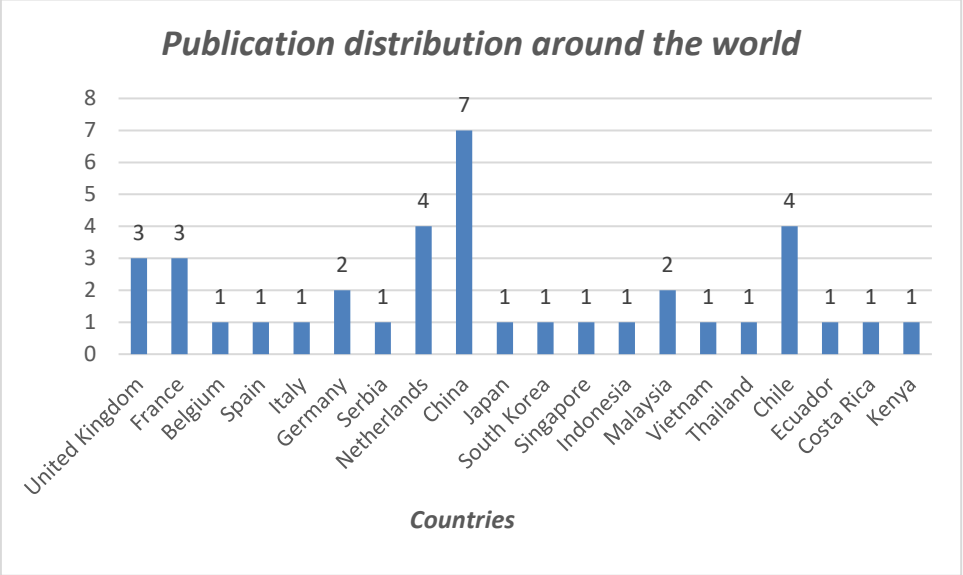

Figure 5: Publication Distribution Globally

Figure 5 illustrates the global distribution of publications, highlighting the disparities in academic contributions across countries within a specific research field. Overall, there was significant unevenness in the distribution, with China leading with seven publications, demonstrating strong research output. This dominance could be attributed to China's increasing emphasis on scientific research supported by favourable policies and funding. China is followed by the Netherlands and Chile, each contributing four publications, indicating notable academic activity. Despite being a small country, the Netherlands likely benefits from its internationalized academic environment and focuses on interdisciplinary research.

The distribution of publications in Europe is relatively dispersed. The United Kingdom and France each contributed three publications, while Belgium, Spain, Italy, and Germany contributed one or two publications each, showcasing the diverse contributions of European countries in this field. Apart from China's remarkable performance, Japan, South Korea, and Southeast Asian countries (such as Malaysia, Vietnam, and Singapore) made modest contributions, with one or two publications each. This may reflect the fact that research in these countries has not yet reached a leading level in this field.

By contrast, research contributions from Latin America and Africa are minimal. For instance, Chile, Ecuador, Costa Rica, and Kenya have only one publication each, possibly owing to limited research resources, insufficient infrastructure, and fewer opportunities for international academic collaboration. Overall, Figure 5 reveals the disparities in research output among countries in this field and provides insights for future exploration of the reasons for these differences.

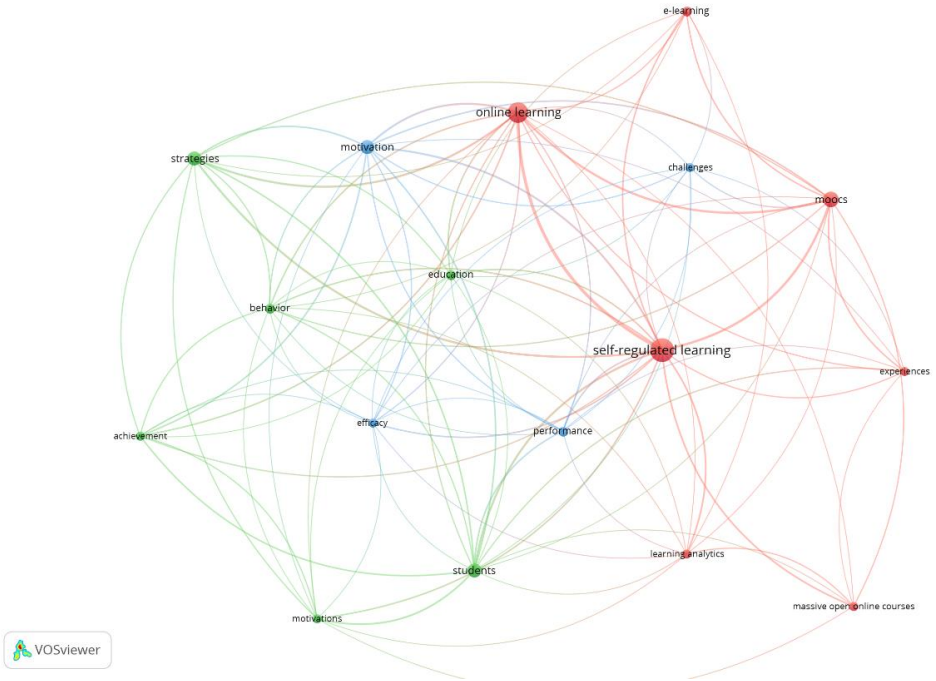

Figure 6: Methodology of the Study of the Relevant Literature

Figure 6 illustrates that research on SRL in online learning environments, particularly within MOOCs and AI-enhanced platforms, has gained substantial momentum between 2014 and 2024. Co-occurrence analysis reveals SRL as a central focus of research, interconnected with concepts such as online learning, performance, and strategies. This finding indicates that SRL is widely acknowledged as a critical factor in promoting academic success and learner autonomy in online learning. However, while MOOCs appear as key terms in the network, their connections to SRL remain less dense compared to other terms, suggesting that the integration of SRL within MOOCs has not yet been fully explored. Similarly, AI's role in SRL is emerging but underdeveloped, as evidenced by the sparse connections between SRL and AI-related keywords, such as learning analytics or adaptive learning systems. Furthermore, motivational and emotional engagement, which are essential components of SRL, are underrepresented in the keyword network, highlighting an area that warrants further investigation. This trend suggests that, although SRL research has expanded significantly, it has predominantly focused on cognitive and behavioural strategies, with emotional and motivational dimensions remaining less prioritized.

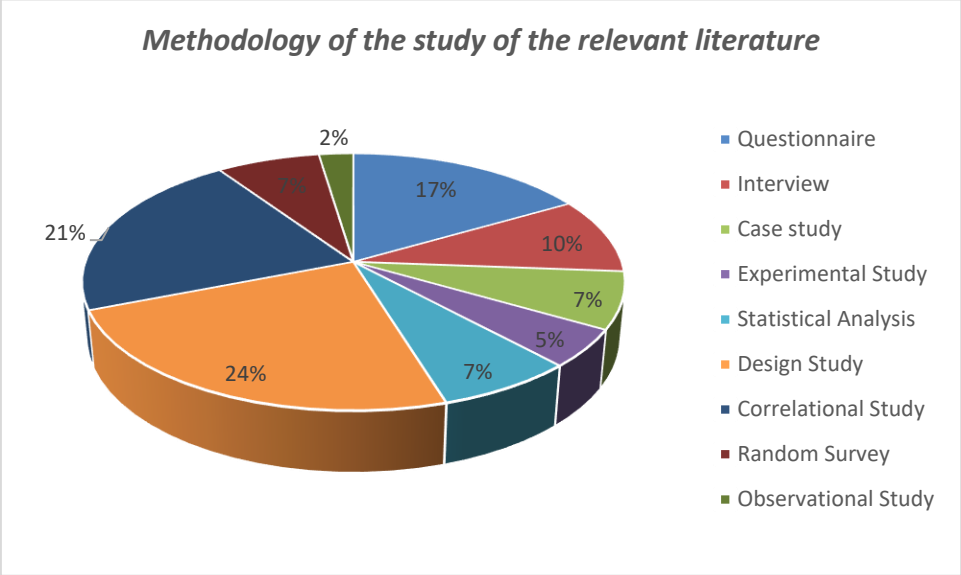

Figure 7: Methodology of the Study of the Relevant Literature

Furthermore, Figure 7 illustrates the distribution of various research methodologies used in relevant studies, highlighting the diversity and focus of the approaches within the field. Among these, questionnaires were the most widely used, accounting for 24% of the total. This indicates a preference for large-scale quantitative data collection, likely owing to its efficiency and wide coverage. Following this, observational studies represented 21%, showing a significant focus on collecting real-world, context-based data, which may be crucial for addressing practical or situational research needs.

Interviews were the third most frequently used method, accounting for 17%, reflecting the importance of obtaining in-depth, qualitative insights. Through interviews, researchers can better understand the motivations and reasoning behind participant behaviour. Case studies, comprising 10%, indicate a focus on the detailed analysis of specific contexts or examples. In contrast, experimental studies, statistical analyses, and correlational studies are less frequently used, accounting for 7% each, suggesting that hypothesis testing and variable relationship exploration are not the primary focus in most of the reviewed literature.

Finally, design studies and random surveys were the least used methods, comprising 5% and 2%, respectively. This may be owing to the higher resource and technical requirements of design studies as well as the complexity of conducting random surveys. Overall, the research methodologies demonstrated a balance of diversity, with a notable emphasis on questionnaires and observational studies. This reflects the researchers' prioritization of broad data collection and context-specific insights, along with some interest in in-depth case analyses and variable relationship studies.

Additionally, this paper analogizes other relevant review articles and integrates the research questions raised, findings, and shortcomings of the study, and displays them in Table 2:

Table 2: Review Studies Based on SRL, MOOC and AI

No	Problem statement	Finding	Limitation
① Learning engagement in massive open online courses: A systematic review. Frontiers in Education (2023) Data source: 2015-2022	1. What are the trends and gaps in the existing literature on learning engagement in MOOCs published from 2015 to 2022? 2. What data analysis methods have been employed in studies on learning engagement in MOOCs, and what are the limitations of these methods? 3. What internal and external factors influence learning engagement in MOOCs, and how have they been addressed in the existing research?	1. Learning engagement can be measured using data from logs, texts, images, interviews, and surveys. 2. Common measurement methods include self-reports (e.g., online learning engagement Scale, MOOC Engagement scale) and automated techniques (e.g., CNN, BERT-CNN). 3. Factors influencing learning engagement are classified as internal or external.	First, future research should obtain more diverse, multimodal data about social engagement. Second, researchers should employ automatic analysis methods to improve measurement accuracy. Finally, course instructors should provide technical support ("scaffolding") for SRL to enhance student engagement with MOOCs.
② Impact of Artificial Intelligence on Learning Management Systems: A Bibliometric Review (2024) Data source: 2004-2023	1. What are the strengths and weaknesses of recent research on the use of AI in learning management systems? 2. What are the most developed lines of research and the emerging areas that remain underexplored in this field? How can the current literature on AI in learning management systems be represented, analyzed, and mapped?	AI in learning management systems enhances personalized and adaptive learning, promotes active and SRL across face-to-face, hybrid, and online environments, and improves students' outcomes, engagement, and motivation. It also boosts accessibility and supports equal access through open educational resources.	The need to develop effective design approaches, evaluation methods, and methodologies to integrate them successfully within classrooms emerged as an issue to be solved. Finally, the need to further explore education stakeholders' AI literacy also arose.
③ Tools to Support Self-Regulated Learning in Online Environments: Literature Review (2018) Data source: 2008-2018	1. What are the commonalities and differences in the design of tools aimed at supporting SRL in online learning environments? 2. What are the effects of these tools on learners' self-regulation in online courses? 3. Which of these tools or design features could be effectively applied in the context of MOOCs?	1. Most studies do not assess the impact on learners' SRL strategies. 2. Interactive visualizations enhance learners' motivation. 3. Social comparison components improve engagement and time management. 4. There is a lack of models linking learners' activities to SRL tools.	1. Enhance underrepresented SRL processes, integrate theoretical frameworks into tool designs, and establish robust evaluation methods. 2. Emphasize developing practical, scalable tools, incorporating prompts for metacognitive support, and using diverse evaluation approaches to assess their real-world impact.

These three review studies provide systematic analyses of learning engagement in MOOCs, application of AI in learning management systems, and tools supporting SRL in online environments. However, significant limitations are evident in these reviews.

First, the scope of these studies is relatively narrow. The first review focuses on learning engagement in MOOCs, categorizing internal and external influencing

factors, and examining common measurement methods, such as self-reports and automated techniques. However, it overlooks the learning engagement characteristics in other online learning formats, such as blended learning or adaptive learning environments, particularly their connection to SRL. The second review emphasizes AI's potential in enhancing personalized and SRL within learning management systems; however, it lacks a deeper exploration of practical implementation, scalability, and interdisciplinary integration. Although AI holds great promise for supporting SRL, most discussions remain theoretical with limited large-scale empirical evidence to validate its effectiveness.

Second, methodological limitations constrain the breadth and depth of the reviews. For instance, the third review examines the design and impact of tools supporting SRL in online courses; however, it highlights that existing studies rarely assess the long-term impact of these tools on learners' SRL strategies. The lack of robust evaluation frameworks makes it difficult to generalize the findings. Although interactive visualizations and social comparison components have been shown to affect motivation and time management positively, no concrete models link these tools directly to learners' SRL processes, resulting in a disconnect between theoretical insights and practical applications.

Finally, although these reviews offer future research directions, their recommendations lack specificity and practicality. For example, a review of MOOCs suggests collecting multimodal data to enhance the understanding of social engagement; however, it provides limited guidance on how to design course structures that effectively stimulate SRL behaviours. The AI-focused review points to the need to improve educators' AI literacy but does not elaborate on actionable strategies to achieve this. Similarly, the SRL tool review calls for practical and scalable tools but provides little detail on how to implement metacognitive prompts effectively in diverse learning contexts.

In conclusion, while these reviews provide valuable insights into SRL, MOOCs, and AI-enhanced learning environments, their limited scope, methodological constraints, and insufficient practical recommendations reduce their broader relevance to the diverse and rapidly evolving field of online education. These reviews often narrowly focus on specific aspects, such as SRL tools or AI applications, overlooking the broader trends and gaps that a comprehensive bibliometric analysis, such as the one conducted in this study, can uncover.

Building on these reviews, this study employs a systematic bibliometric approach to analyze trends and patterns in SRL research from 2014 to 2024, with particular attention to the interplay between SRL, MOOCs, and AI-enhanced platforms. Unlike previous reviews, this research addresses these gaps by synthesizing findings across diverse contexts, identifying underexplored areas, such as emotional and motivational dimensions, and highlighting the limited representation of diverse learner groups and geographic regions. Future reviews should continue to adopt interdisciplinary approaches, prioritize longitudinal and empirical validations, and propose scalable and context-sensitive solutions to bridge the gap between theory and practice. By addressing these limitations,

future studies can better support the dynamic demands of online education and contribute to more inclusive, equitable, and impactful learning practices.

6. Discussion

This bibliometric analysis provides critical insights into the current research landscape of SRL in online learning environments, particularly focusing on MOOCs and AI-enhanced platforms between 2014 and 2024. By addressing these three research questions, this study highlights significant findings, limitations, and implications for future research. To address the main findings and shortcomings of the literature, this review identifies several critical gaps. The integration of AI into SRL research is still in its infancy, with limited exploration of its ability to provide real-time support and facilitate emotional engagement. The uneven global distribution of research contributions points to disparities in resource allocation and academic collaboration, which may hinder the generalizability of the findings across diverse educational contexts. Moreover, although SRL strategies positively impact online learning outcomes, most studies lack robust evaluation frameworks for measuring their long-term effects.

The period from 2020 to 2024 marked a transformative phase for SRL research catalyzed by the COVID-19 pandemic. This period saw a surge in studies examining the role of SRL in emergency remote learning and online education (Stracke et al., 2022). The urgent need for adaptable and autonomous learning strategies during this period also places SRL at the forefront of educational research (Berger et al., 2021). The emotional and motivational dimensions of SRL, previously underexplored, have gained attention as researchers have recognized their critical role in maintaining learner engagement during prolonged periods of isolation. Emotional and motivational dimensions are critical for sustaining engagement and overcoming challenges in self-regulated learning environments. They play a pivotal role in helping learners navigate affective challenges and maintain motivation, particularly in online and autonomous learning contexts (Zheng et al., 2023). However, existing research has largely overlooked these dimensions, focusing instead on cognitive and metacognitive strategies (Panadero, 2017). This oversight limits our ability to understand fully how learners manage affective challenges, thereby constraining the development of targeted interventions. Addressing this gap is crucial for fostering emotional resilience and motivation, which are key to achieving long-term learning goals. Moreover, integrating emotional and motivational support into SRL frameworks and leveraging AI technologies such as real-time emotion recognition (Choksi et al., 2024) could provide more effective and adaptive learning environments. Future research should prioritize these aspects to build a more comprehensive understanding of SRL.

The primary focus of this review on MOOCs and AI-enhanced platforms stems from their transformative impact on online education and their unique reliance on SRL strategies. MOOCs, as large-scale, open-access courses, demand high levels of learner autonomy because of minimal instructor interaction and lack of structured schedules (Kizilcec et al., 2017). Most studies have focused on university-level students, with limited attention paid to adult learners, healthcare

professionals, or linguistically diverse populations. This is consistent with the findings of Broadbent and Poon (2015), who observed that SRL research primarily addresses traditional academic settings with limited exploration of non-traditional learners. Similarly, a review by Dent and Koenka (2016) emphasized that SRL strategies are critical for fostering academic success, engagement, and autonomy; however, these studies rarely address the unique challenges faced by adult learners or professional trainees in diverse contexts.

AI technologies have also emerged as game changers with AI-enhanced platforms offering dynamic, personalized learning experiences, enabling real-time feedback, adaptive pathways, and scaffolding of SRL processes such as goal setting and monitoring (Jin et al., 2023). These environments highlight the critical role of SRL in fostering engagement and success, which justifies their prioritization in this review. However, it is essential to consider how the findings of this study can be extended to other forms of online learning. For instance, blended learning environments integrate online and face-to-face components, thus requiring students to regulate their learning across multiple modalities. The strategies highlighted in this review, such as self-monitoring and goal setting, are equally applicable to these contexts as they support the transition between autonomous and guided learning (Bernard et al., 2014). Similarly, asynchronous courses, which share similarities with MOOCs in terms of flexibility, also require robust time management and self-discipline, making the SRL frameworks discussed here relevant (Alhazbi & Hasan, 2021). Geographically, this research is dominated by contributions from China and Western countries, with minimal representation from Africa and Latin America, suggesting a need for more diverse and inclusive studies. This uneven distribution limits the generalizability of the findings and highlights the urgent need for more diverse and inclusive research.

This review's findings can be effectively connected to Zimmerman's cyclical model of SRL which highlights the phases of forethought, performance, and self-reflection (Zimmerman, 2000). AI-driven tools and MOOCs align with these phases by facilitating personalized goal setting (Jin et al., 2023), real-time feedback, and reflective evaluation processes. For instance, AI-enhanced platforms support the forethought phase through adaptive learning pathways and goal-setting prompts, whereas real-time feedback mechanisms enhance learners' ability to monitor progress during the performance phase. Reflective prompts and performance analytics also aid in self-reflection by helping learners evaluate outcomes and plan for future improvement. However, Zimmerman's model focuses primarily on cognitive and metacognitive processes, leaving gaps in addressing emotional and motivational regulation, which are critical in online learning environments. This review suggests theoretical advancements by integrating emotion regulation into SRL frameworks, particularly through tools such as real-time emotion recognition and regulation (Zheng et al., 2023).

Regarding the tools and methods used to support SRL, questionnaires emerged as the most common research tool, emphasizing large-scale quantitative data collection. This is in line with Vilkova's (2020) findings, which highlighted the prevalence of questionnaire measures in SRL studies owing to their ease of

administration and scalability. While these tools are efficient for large-scale data collection, they are prone to biases, such as social desirability and recall inaccuracies. Learners may overestimate their self-regulation abilities or fail to recall their learning behaviours accurately, leading to discrepancies between reported and actual practice. AI-based tools, including adaptive learning systems and personalized feedback mechanisms, have demonstrated the potential to enhance SRL by supporting goal setting, self-monitoring, and time management. This finding aligns with that of Lai (2024), who documented the growing use of AI technologies to tailor learning experiences and provide real-time feedback. Despite these advancements, the scalability and long-term effectiveness of such tools remain under-researched. Furthermore, an abundance of online resources often leads to cognitive overload for learners with weaker SRL skills, highlighting the importance of designing user-friendly interfaces and structured learning environments. Long-term studies tracking learners' SRL strategies across multiple courses or semesters can reveal how self-regulation evolves over time. Such designs are particularly relevant for assessing the sustained impact of SRL interventions and AI-driven tools on online learning.

The findings of this study have theoretical and practical implications. Theoretically, this research expands the understanding of SRL by highlighting the underexplored emotional and motivational dimensions that play a critical role in sustaining learner engagement. Additionally, this research calls attention to geographic and demographic disparities in SRL studies, emphasizing the necessity of conducting culturally diverse research to enhance the cross-contextual validity of SRL theories. From an applied perspective, the results demonstrate the potential of AI-driven tools such as adaptive learning systems and real-time feedback mechanisms to support SRL processes, including goal setting, self-monitoring, and emotional regulation. However, the design of these tools must prioritize scalability, user friendliness, and effectiveness across diverse learning contexts. The findings also advocate the development of personalized learning pathways facilitated by AI technologies to address challenges, such as cognitive overload and disengagement in MOOCs.

Building on the findings of this study, several directions for future research have emerged, offering both theoretical and practical benefits. First, the geographic concentration of current studies in China and Western countries highlights the need to explore SRL strategies across diverse cultural contexts, particularly Africa and Latin America. Such research can uncover the variations and commonalities in SRL practices, ultimately enhancing the global applicability of theoretical frameworks and contributing to cross-cultural advancements in online learning. To address the inclusivity challenges, SRL research can adopt participatory design approaches that involve learners from diverse backgrounds in the co-creation of interventions. Furthermore, the integration of AI with SRL remains in its infancy despite the demonstrated potential of AI tools in supporting SRL processes. Future studies should systematically investigate the role of AI in providing real-time feedback, emotional regulation, and personalized learning pathways, thereby addressing gaps in understanding its long-term impact and scalability. A promising avenue for future research is the use of longitudinal studies to assess

the enduring effects of SRL interventions. Long-term tracking of learners' performance, engagement, and behavioural changes can provide insights into how SRL strategies evolve and adapt over time. For instance, researchers could explore how specific interventions such as goal-setting prompts or adaptive learning pathways influence learners' self-regulation capabilities across multiple academic terms or years (Berger et al., 2021).

7. Conclusion

In conclusion, this review highlights the critical role of SRL in online education and examines the potential of AI-driven tools to transform learning experiences. Based on the findings of this review, the proposed integration of AI tools into SRL strategies demonstrates notable advantages over traditional approaches. Specifically, AI tools offer enhanced personalization and scalability, allowing learners to receive tailored feedback and support, which is often lacking in traditional SRL methods. Moreover, AI can dynamically adapt to individual learners' needs, addressing both cognitive and metacognitive challenges more effectively than static or one-size-fits-all frameworks can.

Despite the significant findings of this review, several limitations of the current body of research warrant attention. First, the predominant focus on cognitive and metacognitive strategies in SRL research has left emotional and motivational dimensions underexplored, despite their critical role in sustaining engagement in online learning. Second, although AI-driven tools show promise in supporting SRL, their scalability, accessibility, and long-term impact remain insufficiently validated, particularly in diverse cultural and socioeconomic contexts. Additionally, the uneven global distribution of research contributions highlights disparities in resource allocation and academic collaboration, which may limit the generalizability of the findings to underrepresented regions such as Africa and Latin America.

Future research should address these gaps by adopting more inclusive methodologies that consider diverse learner populations and their unique characteristics. Longitudinal studies are needed to evaluate the long-term effectiveness of SRL interventions, particularly those that integrate AI tools. Furthermore, the development of comprehensive frameworks that incorporate the cognitive, metacognitive, emotional, and motivational dimensions is crucial for advancing our understanding of SRL in online learning environments. By addressing these limitations, future research can provide more holistic and actionable insights, ultimately enhancing the learning experience of students in increasingly digital and globalized educational settings.

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