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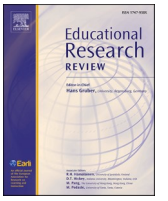

Review

Synthesizing research evidence on self-regulated learning and academic achievement in online and blended learning environments: A scoping review

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ABSTRACT

The present study synthesizes research evidence on self-regulated learning (SRL) and academic achievement in online and blended learning environments from intervention and cross-sectional studies. We examined 163 studies conducted in various countries and different learning contexts in terms of study characteristics, methodology, and SRL features. The current study found that SRL in the online and blended learning contexts has been an important topic and has received increased attention. The results revealed the importance of SRL for improving students' academic performance in the STEM field. It also demonstrated that the majority of the studies adopted multiple SRL strategies throughout mixed phases. This study confirmed the effectiveness of SRL on academic achievement in online or blended learning. However, the present study also identified that research on children's and adolescents' SRL strategies in online learning contexts is urgently needed and most of the available research did not focus on the preparatory and planning phases of SRL which are extremely important.

1. Introduction

Online education has increasingly become prevalent across the 21st century but became an especially important form of learning out of necessity during the COVID-19 global pandemic in 2020. For example, the National Center for Education Statistics (2022) reported that the number of undergraduate students enrolled in completely online education was 186 percent higher in 2020 than in 2019. With this shift to online and blended education, the importance of student emotions, motivation, and engagement in self-regulated learning (SRL) to be effective became very evident. The pandemic highlighted the need for students to be able to manage or regulate their emotions such as anxiety or loneliness and to stay motivated and attentive to successfully learn and achieve academically, particularly in online education. Indeed, many consider e-learning as an essential approach for education that will persist into the post-COVID era (Hodges, Moore, Lockee, Trust, & Bond, 2020). Given the importance of SRL in online and blended learning environments, it is important to evaluate and synthesize the extant research on SRL, including the different types of SRL

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strategies and academic performance. Understanding which SRL strategies are associated with academic performance is critical for effectively designing and implementing online and blended learning curricula or interventions. To address this need, this scoping review identifies and analyzes the scope of the extant research on the relationship between SRL and academic performance in online and blended learning environments.

SRL refers to a process that involves efforts to manage and direct complex learning activities (Zimmerman & Schunk, 2011). Pintrich (2000) defines SRL as an active and constructive process whereby learners set goals and attempt to monitor their cognition, motivation, and behavior. SRL is regarded as one of the key components for predicting learning performance, and learners with a high self-regulation ability improve their engagement in learning activities and thus academic achievement (Jansen, Van Leeuwen, Janssen, Jak, & Kester, 2019). However, the role of emotions in SRL has historically received limited attention. Researchers have increasingly emphasized the importance of emotions and emotional regulation in theories of SRL, because studies have shown that emotions and emotional regulation impact motivation, attention, and learning outcomes (Ben-Eliyahu & Linnenbrink-Garcia, 2013).

Multiple models aim to explain the SRL process (Verma, Ahuja, & Hermon, 2018). According to a theoretical review (Puustinen & Pulkkinen, 2001) and the *Handbook of Self-Regulation of Learning and Performance* (Zimmerman & Schunk, 2011), models proposed by Zimmerman, Boekaerts, Pintrich, Borkowski, and Winne are widely used in research. Puustinen and Pulkkinen (2001) reviewed these different models and concluded that SRL proceeds from a preparatory phase, through a performance phase, to an appraisal phase. In the preparatory phase, learners analyze tasks, make plans, and set goals. The performance phase includes strategy use, monitoring, and control. In the appraisal phase, students engage in reflection and evaluation of learning (Pintrich, 2000; Puustinen & Pulkkinen, 2001).

Cognitive, metacognitive, resource management, and emotional management SRL strategies are employed throughout these phases (Puzziferro, 2008). Cognitive strategies include rehearsal, elaboration, and organizational strategies that learners utilize to regulate their cognition (Weinstein & Mayer, 1986). Metacognitive strategies refer to the awareness about cognitive processes, including planning, monitoring, and reflecting on learning. Resource management strategies require learners to make use of internal or external resources (e.g., peers, instructors, effort, attention) (Jansen et al., 2019; Puzziferro, 2008). Lastly, emotional regulation is also one of the main areas that SRL explores, although emotional regulation has been under-studied in the SRL research literature (Oxford, 2017; Panadero, 2017). According to Winne & Hadwin (1998), emotions can influence learning and academic engagement as well as serve as affective or evaluative feedback of one's learning and performance. Therefore, studies related to SRL and the sub-components of SRL — cognition, metacognition, resource management, and emotional regulation — are the scope of the current review.

1.1. The associations between self-regulated learning and academic performance

Empirical studies have consistently demonstrated the effectiveness of SRL on academic achievement (Azevedo & Cromley, 2004; Chen & Huang, 2014; Sadati & Simin, 2016). Students' use of SRL strategies is considered to offer a distinct advantage to their learning and academic outcomes (Zimmerman, 1990). Strategies such as goal setting and planning have been demonstrated to be positive predictors of goal attainment (Kizilcec, Pérez-Sanagustín, & Maldonado, 2017). Meanwhile, SRL could also affect academic achievement in an indirect way. For example, students tend to engage in effective cognitive strategies when they actively self-regulate their learning, which results in learning progress (Jansen et al., 2019).

1.2. Self-regulated learning in E-learning environments

With the rapid growth of technology, the ways people learn or acquire new knowledge have been transformed. One significant change is that an increasing number of students choose to undertake their education online. Online learning is defined as a learning process in which learners use the internet to obtain learning materials, external support, and interactions with instructors and other learners (Ally, 2004). Blended learning refers to the integration of face-to-face learning and online learning (Garrison & Kanuka, 2004). These two settings constitute the main applications of e-learning (Garrison & Anderson, 2003), which is the primary context this study focuses on. Compared to traditional face-to-face learning, students have more access to learning resources and greater collaboration opportunities in e-learning environments (U.S. Department of Education, 2009). E-learning could also provide flexibility and accessibility for students who have difficulty attending class in-person (Waschull, 2001). However, success in online and blended learning environments requires learners to be more independent and to engage in the learning process autonomously and actively (Broadbent & Poon, 2015). This places an increased demand for self-regulation on students' engagement in e-learning contexts.

Researchers have explored various approaches to support SRL in online and blended environments (Delen & Liew, 2016). Computer-based tools have been designed for assessment of SRL to provide learners with feedback and thus improve their SRL. For example, Perry and Winne (2006) collected time-stamped trace data by gStudy software to assess students' self-regulated engagement. In the edX platform, a widget was developed to display performance indicators to support learners' SRL (Davis, Chen, Jivet, Hauff, & Houben, 2016). Web-based tools have also been developed to improve SRL skills by focusing on improving learning strategies such as goal setting and strategic planning (Shih, Chen, Chang, & Kao, 2010). SRL in online learning could also be promoted through the optimization of the learning materials. Technologies make it possible to recommend individual learning content based on learners' competence and schedule (Kopeinik et al., 2014; Yau & Joy, 2008). Additionally, online learning allows for SRL through interaction with diverse forms of learning material. For instance, knowledge visualization can provide metacognitive support by helping learners plan, monitor, and reflect on their learning process (Wang et al., 2011).

1.3. Reviews from Pre-COVID era

A number of reviews have focused on SRL interventions as well as SRL and academic achievement in various contexts. Two meta-analyses published in 2008 examined the effectiveness of SRL interventions. Dignath, Buettner, and Langfeldt (2008) analyzed the impact of SRL on primary school students by reviewing 30 articles published between 1992 and 2006. They reported a positive effect size for SRL training programs on learning outcomes, SRL strategy use, and motivation. With similar research objectives, Dignath and Büttner (2008) conducted a meta-analysis with both primary and secondary school students. Results revealed an average effect size of 0.69, and several moderators such as subjects and strategies were identified.

In the past decade, several reviews explored SRL interventions in online contexts (see Table 1). Focusing on computer-based learning environments, Devolder, van Braak, and Tondeur (2012) reviewed SRL scaffolds in science education and identified prompts as the most effective support. Likewise, Pérez-Álvarez, Maldonado-Mahauad, and Pérez-Sanagustín (2018) analyzed 22 tools to support SRL in online settings. Results indicated that the use of interactive visualizations could positively influence motivation and tools, including social comparison components improved time management ability and engagement. Two systematic reviews published in 2019 discussed SRL in massive open online courses (MOOCs). Strategies in behavioral, motivational, and contextual regulation were identified in the review by Lee, Watson, and Watson (2018), and they proposed several SRL interventions in MOOCs. In the other systematic review, Wong et al. (2019) discussed SRL supports in MOOCs and the important role of human factors in these supports.

As for the correlation between SRL and academic performance, four meta-analyses have been published; three of them were conducted in the higher education context. After reviewing 126 studies about SRL strategies used by university students, Richardson, Abraham, and Bond (2012) identified seven strategies that can predict grades significantly, and the weighted mean correlations were from 0.15 to 0.32. Jansen et al. (2019) performed meta-analyses on 142 studies to explore the relationships among SRL interventions, SRL activities, and academic achievement for university students. Although SRL interventions were found to be effective in enhancing SRL activities and achievement, the indirect effect of SRL interventions on achievement was small. These two meta-analyses did not differentiate online or blended learning from traditional learning formats.

Broadbent and Poon (2015) also chose higher education as the research context but exclusively focused on online settings. They evaluated 12 empirical studies published from 2004 to 2014 to explore the relationship between SRL strategies and academic performance. Broadbent and Poon (2015) concluded that the SRL strategies of time management, metacognition, effort regulation, and critical thinking had positive correlations with academic achievement. Similarly, the meta-analysis by Zheng (2016) demonstrated a medium positive effect (ES = 0.438) of SRL scaffolds on academic achievement in computer-based learning environments. Li, Ye, Tang, Zhou, and Hu (2018) turned to SRL phases and strategies for primary and secondary school students in China and indicated that the effect size of SRL on academic performance was small and decreasing over years. Adam, Alzahri, Cik Soh, Abu Bakar, and Mohamad Kamal (2017) conducted a systematic review investigating SRL in online mathematics learning. After reviewing more than 150 articles published between 1986 and 2017, Adam et al. (2017) concluded that online SRL strategies positively improved learners' mathematics learning.

Table 1
Previous reviews on SRL.

Former Reviews	Analytical Approach	Time Period	Included studies	Education level	Review Focus
Adam et al. (2017)	Systematic review	1986–2017	more than 150	all education levels	Mathematics and SRL via online learning
Broadbent and Poon (2015)	Meta-analysis	2004–2014	12	higher education	SRL strategies associated with academic outcomes in online settings
Devolder et al. (2012)	Systematic review	2001–2011	28	all education levels	Scaffolds that support SRL processes in science education
Dignath and Büttner (2008)	Meta-analysis	1992–2006	84	primary and secondary school	Impact of SRL training on academic performance, strategy use, and motivation
Dignath et al. (2008)	Meta-analysis	1992–2006	30	primary school	Effectiveness of SRL interventions
Jansen et al. (2019)	Meta-analysis	by 2016	126	higher education	Whether SRL activity mediates the effect of SRL interventions on achievement in higher education
Lee et al. (2018)	Systematic review	2014–2016	21	not limited to 1 level (MOOCs)	Empirical research on SRL in MOOCs
Li et al. (2018)	Meta-analysis	1998–2016	59	elementary and secondary school	Association between self-regulation and academic performance
Pérez-Álvarez et al. (2018)	Literature Review	not specified	38	not limited to 1 level (MOOCs)	Tools designed to support SRL in online environments
Richardson et al. (2012)	Meta-analysis	1997–2010	126	university students	SRL strategies and GPA (There are 5 research domains in this paper.)
Sitzmann and Ely (2011)	Meta-analysis	not specified	369	adults	Interrelations among the self-regulation constructs and their effects on learning
Wong et al. (2019)	Systematic review	2006–2016	35	not limited to 1 level (MOOCs)	Effectiveness of approaches to support SRL strategies in online learning environments
Zheng, Li, and Chen (2018)	Meta-analysis	2004–2015	29	all education levels	Effects of self-regulated learning scaffolds on academic performance in computer-based learning environments

Based on these previous reviews, SRL in online contexts has received increasing attention. However, literature about SRL and academic performance in online or blended contexts remains relatively limited and rarely integrated across learning contexts. Some scholars have touched on the relationship between SRL and learning outcomes in these learning contexts, but their research scopes in terms of educational level and subject are limited (Adam et al., 2017; Broadbent & Poon, 2015; Li et al., 2018). Therefore, additional comprehensive and systematic reviews about this topic are needed. The present study aims to provide an up-to-date scoping review of intervention and cross-sectional studies on SRL and academic achievement in diverse e-learning settings.

2. Research questions

The present scoping review aims to investigate: 1) study design; 2) methodology; 3) SRL practices; 4) achievement outcomes; and 5) different online or blended learning contexts. The current study is guided by the following research questions:

- What are the substantive features of the included studies, such as publication information and learners' educational levels?
- What are the methodological features of the included studies, such as the research methods employed and sample sizes?
- What is the impact/influence of SRL on students' academic achievement in online and blended learning environments?
- What are the characteristics of the SRL in the included studies, such as SRL strategies used, SRL phases, and SRL triggers?

3. Method

Our research questions focus on describing the research about the influence or impact of SRL on students' academic achievement in online and blended learning environments. Scoping reviews are appropriate to investigate the scope of literature on a topic, where additional research should be undertaken, and how research is conducted on a topic (Khalil et al., 2021; Pollock et al., 2021). Thus, the scoping review method is best aligned with our study's purpose. A scoping review utilizes a comprehensive search to identify eligible studies, does not appraise the quality of included studies, and descriptively summarizes the results from studies that use different research designs (Arksey & O'Malley, 2005).

To conduct this scoping review, we used Arksey and O'Malley's (2005) scoping study framework and incorporated elements from more recent literature (Pollock et al., 2021; Khalil et al., 2021), which extend Arksey and O'Malley's framework. First, we identified the research questions, using the "Population, Concept, and Context" approach to articulate the overarching aim of the study (Pollock et al., 2021). The population was all levels of learners, the concept was SRL, and the context was online and blended learning. Then, we searched for and selected relevant studies. As Pollock et al. (2021) recommended, an experienced education librarian, the fifth author, recommended appropriate databases and developed the search strategy for each database. Next, data from the included studies was charted using a coding form. When disagreements occurred between two coders, a third coder was consulted to resolve the disagreement (Pollock et al., 2021). Finally, elements from the coding form were summarized and reported using descriptive statistics (Khalil et al., 2021; Pollock et al., 2021). As recommended by Pollock et al. (2021) and Khalil et al. (2021), we followed the PRISMA-ScR checklist (Tricco et al., 2018) for reporting our scoping review methods, which identifies the key elements to include when writing a scoping review to improve methodological transparency.

3.1. Study search

The fifth author, an education librarian, developed comprehensive database searches to locate potential articles. The search was developed in ERIC (EBSCO) and modified for APA PsycInfo (EBSCO), Education Source (EBSCO), Academic Search Ultimate (EBSCO), and Computer Source (EBSCO). Three core concepts comprised the search: self-regulation, online and blended environments, and academic achievement. Synonyms for each concept were searched in the title and abstract fields, and relevant database subject terms were searched in the subject field. Search terms included *self-regulation, cognitive strategy, metacognitive technique, rehearsal, elaboration, monitoring, self-evaluation, online, internet, virtual, web-based, e-learning, distance education, achievement, academic ability, grade, test, indicator, academic performance, exam, GPA,* and *learning outcome.* The complete search strategy for ERIC is included in the supplementary materials. Each database search was limited to between January 1, 2011 and March 16, 2022. The combined searches retrieved 7171 results.

3.2. Inclusion and exclusion criteria

3.2.1. Included studies met the following five criteria

1. The included studies examined the effect of SRL on learners' academic achievement or the relationship between SRL and students' academic achievement in online and blended learning environments. Articles were excluded if they were not about SRL, if they did not include learners' academic achievement, or if they were not conducted in online or blended learning environments.
2. The included studies had to be published in a peer-reviewed journal or reported in a dissertation from January 1, 2011 to March 16, 2022, and available in English. We chose the time frame because we aimed to include the most recent studies after the publication of the *Handbook of Self-Regulation of Learning and Performance* (Zimmerman & Schunk, 2011). Secondary data analyses, literature reviews, conference papers, and book chapters were excluded.

3. Included studies reported empirical evidence—qualitative or quantitative—on students' learning outcomes. Articles were excluded if they reported students' changes of self-regulation strategies or students' psychological transformation. Although the influence of self-regulation strategies on students' psychological state is of critical importance, this scoping study aimed to focus on the effect of SRL on learners' academic achievement under online or blended contexts. Articles that focused solely on self-regulation strategy design were also excluded.
4. Included studies were conducted in online or blended learning environments. Articles were excluded if they conducted SRL interventions in face-to-face classrooms or investigated the relationship between SRL and students' learning achievement using traditional instruction methods.
5. All levels of learners were included, encompassing kindergarten to adults. Study samples could contain normal learners and special needs learners from the formal education system to any type of informal education.

3.3. Coding scheme

A detailed coding scheme was designed to organize study information and facilitate data extraction. We covered the studies' substantive and methodological features through the designed coding form. Since the focus of the study is on the effect of SRL on learners' academic achievement or the relationship between SRL and students' academic achievement in online or blended learning contexts, we categorized the SRL strategy types, SRL triggers, SRL phases, SRL models, and SRL measures.

3.3.1. Substantive features of the studies

Substantive features of the studies included publication information, participants' country, intervention type, intervention duration and intensity, participants' subject area or discipline, learning context, and education level.

We coded the publication type as a journal article or dissertation. We also analyzed the publication years. By coding publication years, we aimed to view the publication trends of SRL on students' academic achievement in online or blended learning environments. For journal articles, we also coded the journal titles to identify the major journals contributing to the field.

For intervention studies, we coded whether the intervention was a pure SRL intervention or an SRL intervention with some other intervention(s). We also coded intervention duration (e.g., weeks) and intervention intensity (e.g., minutes per week) to understand the interventions' characteristics in the field.

The education levels were divided by elementary (K-6), secondary (7-12), higher education (undergraduate and graduate), and informal education. If the studies' participants were from more than one level, they were coded as mixed. We coded learners' subjects as STEM (science, technology, engineering, and mathematics) and non-STEM (Vo, Zhu, & Diep, 2017). If the studies covered general subjects, including both STEM and non-STEM subjects, they were coded as mixed. Table 2 presents the subjects classified as STEM disciplines and non-STEM disciplines in the included studies.

3.3.2. Methodological features of the studies

Methodological features of the studies included study type, research methods, sample size, and test outcome measures. Study types were coded as intervention studies or correlation studies. Research methods were defined by three approaches: quantitative (with statistical procedures), qualitative (without statistical procedures), and mixed-method, a combination of the two. We also documented the sample size within the included studies. For test outcome measures, we classified the studies into standardized outcome measures, researcher-designed outcome measures, and mixed, a combination of the two.

3.3.3. Categorization of SRL types and SRL measures, academic performance, and learning context

If SRL intervention/correlation studies were found to have positive effects or correlate positively with learners' academic performance, we coded them as positive and vice versa. If no significant effects were found, we coded them as nonsignificant. If the intervention studies or correlation studies had mixed effects, we coded as mixed.

The learning context was identified based on where the study was conducted. If a study was conducted in an online course, online learning system, mobile environment, or in any web-based video, software, programs, and multimedia, it was coded as online. If the study was conducted in both online and traditional learning contexts, it was coded as blended.

For the characteristics of SRL, we first coded the SRL measures, SRL strategies, and SRL phase for all the included studies, both

Table 2
STEM vs. Non-STEM Disciplines.

STEM	Non-STEM
Mathematics	Language
Science	Learning Sciences
Statistics	Psychology
Chemistry	Education
Biology	History
Engineering	Business and Economics
Medical Science	Creativity-Liberal
Anatomy and Physiology	
Gerontology	

intervention studies and correlation studies. SRL measures were coded into four categories: modified questionnaires such as Motivated Strategies for Learning (MSLQ), self-designed measures, behavioral coding, and mixed measures. SRL strategies were categorized as cognitive, metacognitive, resource management, and emotional strategies. If the study employed more than one strategy, it was coded as mixed. SRL phases included preparatory, performance, and appraisal. If the study involved more than one phase, it was coded as mixed. In correlation studies, the SRL strategies and SRL phases indicated what strategies and which phase the study focused on. For intervention studies, these indicated what strategies and the phase at which the SRL intervention was aimed.

SRL trigger was also coded for intervention studies. Adhering to Zheng's (2016) coding scheme, we coded SRL triggers as prompts or hints, concept maps, integrated SRL tool, worked examples, videos, and notes.

3.4. Data collection and data analysis

The search and screening process to identify eligible studies is shown in Fig. 1. After deduplication, 5458 unique references were screened for eligibility. First, the first two authors screened the article titles and abstracts using the inclusion/exclusion criteria. After the first round of screening, more than 90% of the articles were excluded. Second, the first two authors independently screened the full text of the remaining 512 articles. After the full-text screening, 149 articles were eligible for inclusion in our review. The 149 articles included 163 independent studies.

The first two authors and the fourth author used the developed coding scheme to code the articles in Microsoft Excel. The initial coding of the 163 studies was done independently in order to calibrate the coding. For the initial round of coding, we achieved an inter-rater reliability of 88.9%. When the three authors had a dispute, the third author was reached to resolve the disagreement. Eventually, 100% agreement about the coding was reached. We conducted descriptive statistical analyses to answer our research questions.

4. Results and discussion

4.1. Findings about the substantive features of the studies

4.1.1. Publication information

The analysis of the publication year of the included articles reflected an even trend in SRL research with students' academic achievement under online or blended learning environments from 2011. We included 149 articles in the present scoping review. Seventy-nine articles (53.02%) were between 2011 and 2016 (six years), and the other 70 articles (46.98%) were between 2017 and 2022 (six years). Among the 149 articles, 110 articles (73.83%) were from peer-reviewed journals, and 39 (26.17%) were doctoral dissertations. The 110 included articles were from 72 peer-reviewed journals. The majority of the journals—75.00% of them ($n = 54$) — appeared once. The other 18 journals (25.00%) showed up more than once. The number of articles per journal included in the current scoping review is listed in Table 3.

4.1.2. Learners' characteristics

Our 149 articles included 163 independent studies. The majority of the studies were conducted in the U.S. ($n = 68$, 41.72%). The

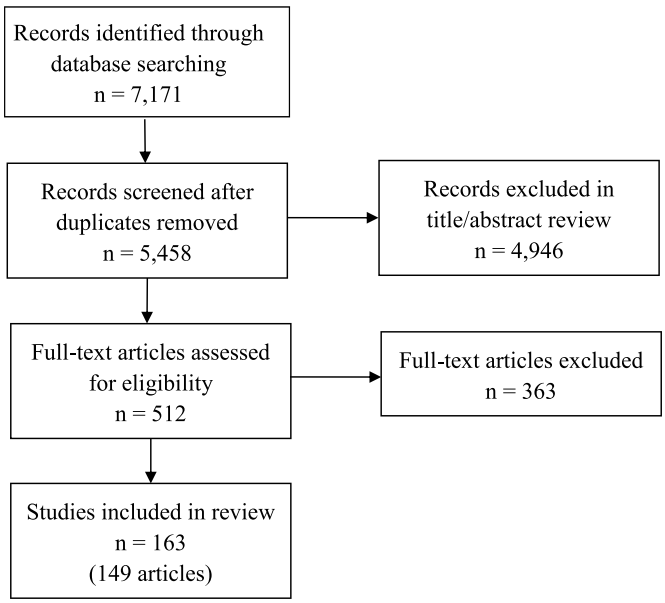

Fig. 1. Flow diagram of the literature searching and screening procedures.

Table 3
Journals of included articles.

Journal	Number of articles per journal
Computers & Education	9
Computers in Human Behavior	6
British Journal of Educational Technology	4
The Internet and Higher Education	4
Contemporary Educational Psychology	3
Distance Education	3
Education and Information Technologies	3
Instructional Sciences	3
Interactive Learning Environments	3
Behavior & Information Technology	2
Computer Assisted Language Learning	2
Educational Technology & Society	2
Journal of Computer Assisted learning	2
Innovations in Education and Teaching International	2
International Forum of Educational Technology & Society	2
International Journal of Emerging Technologies in Learning	2
International Journal of Information and Communication Technology Education	2
IEEE Transactions on Learning Technologies	2
Other journals (e.g., Journal of Educational Computing Research, Frontiers in Psychology)	*54

Note: *Other articles only appear once but in separate journals.

other countries occurring more than once were Taiwan (n = 22, 13.50%), the Netherlands (n = 8, 4.91%), Australia (n = 7, 4.29%), Germany (n = 6, 3.68%), Korea (n = 6, 3.68%), China (n = 6, 3.68%), Turkey (n = 5, 3.07%), Indonesia (n = 4, 2.45%), Saudi Arabia (n = 3, 1.84%), Malaysia (n = 2, 1.23%), and Hong Kong (n = 2, 1.23%). Three studies (1.84%) did not specify where the study was conducted. The other 21 studies (12.88%) were conducted in countries like Canada, Indonesia, Australia, Chile, and the United Kingdom. More than 36 percent (n = 60, 36.81%) of the included studies were conducted in Asia-Pacific areas, such as Taiwan, China, Hong Kong, Australia, and Japan. This finding is consistent with the previous reviews that examined the geographical distribution of studies about educational technology's impact on learners' academic performance (Lee, Kuo, Xu, & Hu, 2020; Xu, Chen, Eutsler, Geng, & Kogut, 2020). In addition to the U.S., the Asia-Pacific region, especially East Asia (e.g., Taiwan, China, and South Korea), actively contributes to research in the field of educational technology (see Fig. 2).

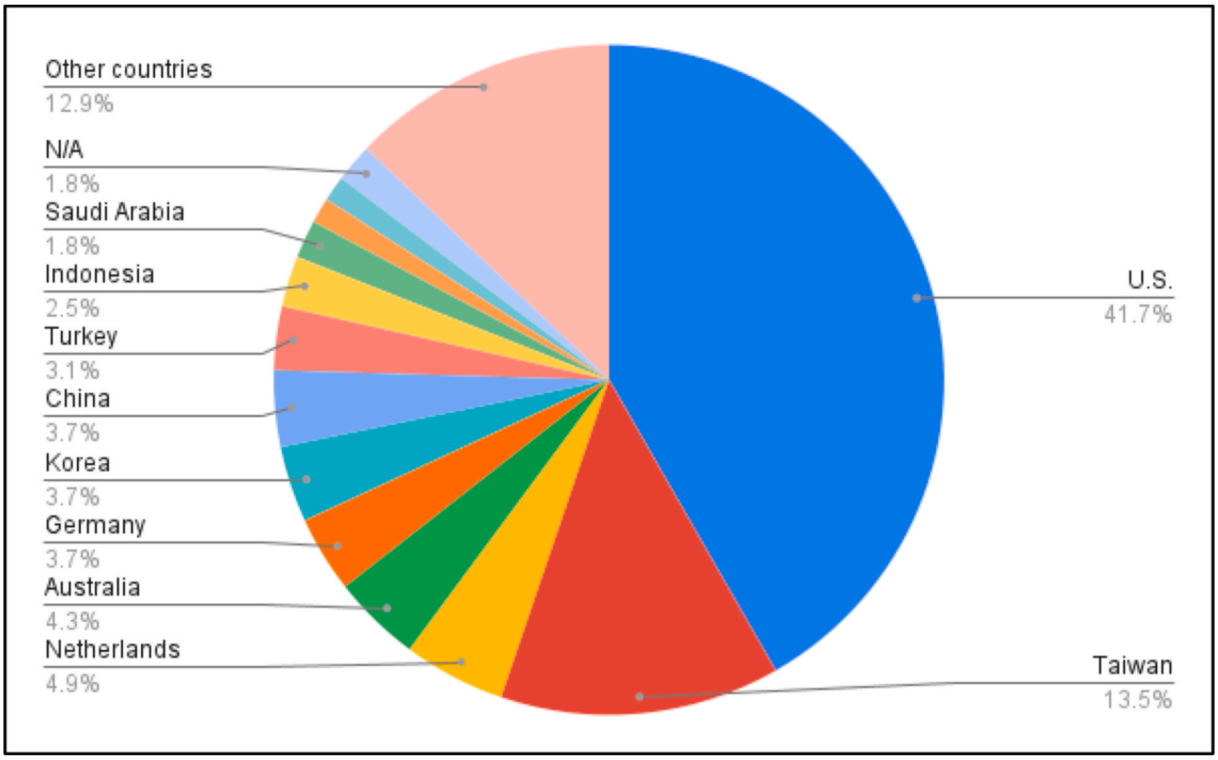

Fig. 2. Distributions of countries covered in SRL studies.

The most prevailing educational level of learners examined in SRL research under online or blended contexts was higher education ($n = 116$, 71.17%), followed by secondary education ($n = 29$, 17.79%). Six studies (3.68%) were conducted at the elementary level, and the other seven studies (4.29%) were from informal education for adult learners. Four studies (2.45%) recruited learners at different educational levels (see Fig. 3). One study (0.62%) conducted by Santosa, Degeng, Sulton, and Kuswandi (2020) did not specify the educational level of participants. The results matched our expectations and also explain why the previous SRL reviews focused on higher education or adult learners (Broadbent & Poon, 2015; Jansen et al., 2019; Sitzmann & Ely, 2011). One potential reason for this is that interventions, especially technological interventions, were more easily conducted with adult learners. Another reason might be that older students have more accurate academic self-perceptions and can better reflect on their cognitive strategies (Harter, 1985; Zimmerman, 1990). With the digitalization in primary and secondary schools, younger students are also expected to employ SRL strategies in online contexts. Thus, our review revealed that more research in K-12 online education is needed to offer younger learners evidence-based SRL support, which is consistent with a previous review (Xu, Zhao, Zhang, Liew, & Kogut, 2022).

As for learners' subject areas, 80 studies (49.08%) were STEM subjects, while 57 studies (34.97%) covered non-STEM subjects. The other 25 studies (15.34%) covered both STEM and non-STEM subjects. One study (0.61%) did not have specific information for its subject area. Our finding that about half of the reviewed studies covered STEM subjects indicated the importance of SRL in improving students' academic performance in the STEM field. This trend can be justified for several reasons. First, STEM disciplines are receiving public awareness in the field of education (Fairweather, 2008). There has been relatively more attention to SRL support in science education than in other domains, like language education (Devolder et al., 2012). Second, STEM disciplines usually involve more research in educational technology. Third, STEM subjects are hard disciplines such as science, technology, engineering, and mathematics. These are usually subjects where students struggle, especially under-represented minority students (Wilson et al., 2012). Thus, the nature of the learning process that STEM subjects require might warrant more need for SRL interventions. Since our focus is on the effect of SRL on learners' academic achievement in online and blended learning environments, it is not surprising that we identified more studies within the STEM category.

4.1.3. Study types

There are 73 (44.79%) intervention studies and 90 (55.21%) correlation studies included in the current scoping review. Among the 73 intervention studies, more than half ($n = 48$, 65.75%) of the interventions are pure self-regulation interventions. The other 25 studies (34.25%) used interventions including both self-regulation and other interventions, such as collaborative learning and problem-based learning (e.g., Kim & Pedersen, 2011; Tsai, Lee, & Shen, 2013). In terms of control group types, a majority of them ($n = 58$, 79.45%) were not using any SRL intervention in online learning environments; nine studies' (12.33%) control groups were not using any SRL intervention offline. There were six studies (8.22%) that did not specify their control group condition. The inadequate information about the control group raised a red flag about the quality of the articles because the control group is essential for determining the effect of the intervention (Boslaugh, 2007).

As part of our analysis, we coded intervention duration and intervention intensity. We followed previous review studies' criteria for intervention intensity and duration (Cheung & Slavin, 2013; Xu, Banerjee, Ramirez, Zhu, & Wijekumar, 2019). If the intervention

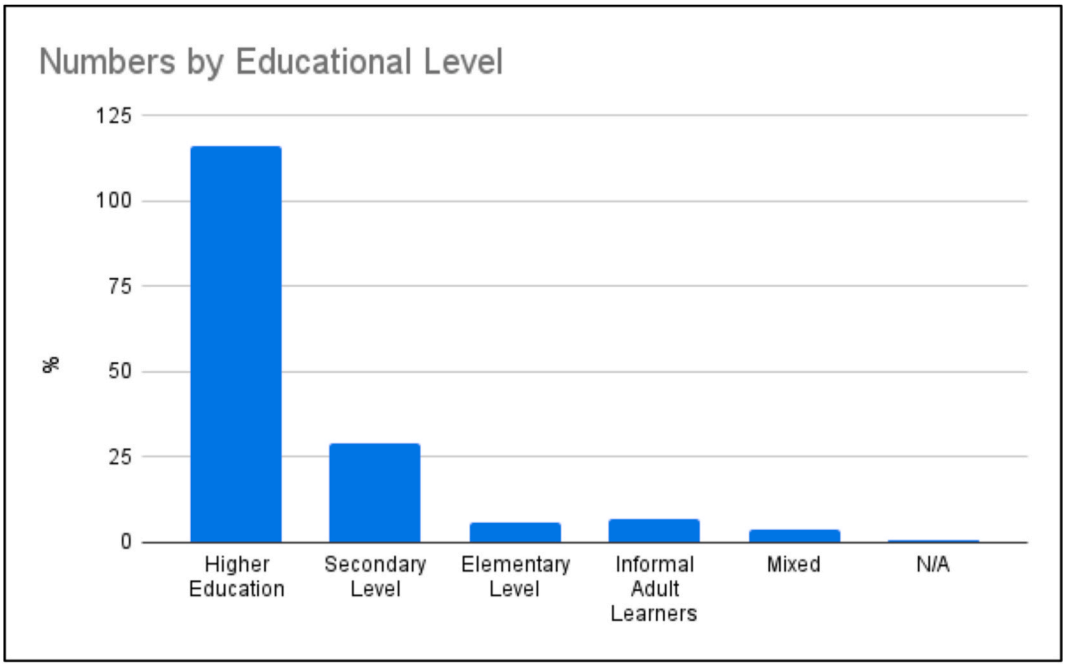

Fig. 3. Distribution of learners' education levels across studies.

lasted for more than 12 weeks, we coded it as long ($n = 21$, 28.77%). Otherwise, we coded it as short ($n = 37$, 50.68%). Fifteen studies (20.55%) did not indicate the interventions' duration. When the intervention was used for more than 75 minutes every week, it was coded as strong ($n = 25$, 34.25%). Otherwise, it was categorized as a weak intervention ($n = 16$, 21.92%). The other 32 studies (43.83%) did not include information about intervention intensity. Our studies' results indicated that a large proportion of studies were not identifying information about intervention duration or intensity. Previous review studies about SRL either did not include both duration and intensity of the SRL intervention or identified contradictory findings about the effect of the SRL intervention duration (Jansen et al., 2019; Wang & Sperling, 2020). However, previous studies also indicated that the intensity and duration of the intervention programs might have an impact on students' achievement (Cheung & Slavin, 2013; Xu et al., 2019). Therefore, researchers in the SRL field might need to factor duration and intensity into their study design and report that important information in the studies for future researchers.

4.2. Findings about the methodological features of the studies

4.2.1. Research methods

We identified the types of research methods used within each of the 163 included studies. The majority of the included studies employed a quantitative methodology ($n = 117$, 71.78%), followed by a mixed-method approach ($n = 46$, 28.22%). This finding is consistent with Xu et al. (2020)'s scoping review about digital game-based technology in English language learning finding that quantitative methods were the most universal approach. Because the focus of the current study is on the effect of SRL on learners' academic achievement, we anticipated that many studies would employ quantitative methods.

We also coded the research design for the 73 intervention studies; we found that 22 studies (30.14%) were randomized controlled trials, while the other 51 studies (69.86%) were quasi-experimental studies. Though we understand that classrooms and schools create challenges for conducting randomized controlled trials, randomized controlled trials are still considered the most reliable way to determine the effectiveness of educational programs or practices (Ginsburg & Smith, 2016). We suggest that future researchers conduct more randomized controlled studies in the field of SRL.

4.2.2. Sample size

According to Slavin and Smith (2009), studies with small sample sizes tend to report larger effect sizes, thus yielding potential bias. Therefore, reporting sample size information is important for critically evaluating studies. Since most of our included studies employed a quantitative methodology, we adhered to the commonly used quantitative research guidelines: studies with less than 100 participants were coded as small samples, studies between 100 and 250 were coded as medium, and studies with more than 250 participants were categorized as large samples (Cheung & Slavin, 2013; Slavin & Smith, 2009; Xu et al., 2020). Among the 163 studies, 45.40% ($n = 74$) involved a small sample size, 36.81% were coded as medium sample size ($n = 60$), and 17.79% qualified as having large sample size ($n = 29$).

4.2.3. Test type

To investigate test outcome measures, we identified data by whether the test was designed by the researchers or was a standardized format. Among the 163 studies, 92.02% of tests were designed by the researcher ($n = 150$), 6.14% used a standardized test ($n = 10$), and 1.84% used both test types ($n = 3$). Researchers often need to develop their own tests to measure a specific outcome within a unique context. However, researcher-designed tests might not be designed with the same rigor that standardized tests employ in terms of subject matter experts and validation of reliability and validity of the constructs examined (Johnson & Christensen, 2008). Thus, the reported effectiveness of researcher-designed tests might not be as accurate as with standardized tests.

4.3. Findings about SRL, academic performance, and learning context

4.3.1. SRL characteristics

With regard to the SRL strategy type, 126 studies (77.30%) adopted multiple SRL strategies rather than exclusively focusing on one strategy. For instance, Coşkun and Ghaemi (2015) investigated the effectiveness of SRL strategy training, which incorporated metacognitive strategies, such as self-evaluation, and cognitive strategies, such as thinking aloud in software named NetSupport School. In Broadbent's (2017) correlation study about SRL and academic performance, multiple SRL strategies, including cognitive, resource management, and metacognitive strategies, were measured by the Motivated Strategies for Learning Questionnaire (MSLQ). Twenty-three studies (14.12%) had a metacognitive focus, and nine studies (5.52%) used a resource management strategy. Only four studies chose cognitive (2.45%), and one study (0.61%) focused on emotion regulation.

With respect to the SRL phase, the majority of studies (134 studies, 82.21%) explored mixed phases. Twenty-five studies (15.34%) focused on the performance phase. The other four (2.45%) studies explored SRL in the preparatory or appraisal phase.

In terms of SRL measures, the most popular measure to assess SRL was a modified scale such as the Online Self-Regulated Learning Questionnaire (OSLQ) and Motivated Strategies for Learning (MSLQ), with 96 studies (58.90%). Nine studies (5.52%) adopted behavioral measures, by which students' behaviors during the learning process were coded. This kind of measure was only identified in correlational studies. For instance, Deekens, Greene, and Lobczowski (2018) used a think-aloud protocol to code participants' micro-level SRL process during learning activities. Sixteen studies (9.82%) adopted self-designed measures, and nine studies (5.52%) used mixed measures. The remaining 33 studies (20.24%) did not specify the SRL measure.

SRL trigger is an important component of an SRL intervention. Among the 73 intervention studies, the integrated SRL tool was

found to be the most common trigger for SRL intervention, with 34 studies (46.58%) adopting it as the trigger. Triggers coded as the integrated SRL tool included SRL strategy assistance for SRL preparatory, performance, and appraisal phrases. For instance, in a web-based program designed to improve adolescents' SRL ability, three metacognitive strategy scaffolds were provided throughout the whole problem-solving process (Kim & Pedersen, 2011). Prompts or hints, identified as the most used SRL scaffold in Zheng (2016), were employed in 14 studies (19.18%). While prompts have been regarded as effective scaffolds, especially in the cognition area (Devolder et al., 2012), few prompts focused on cognitive strategies (e.g., Bednall & Kehoe, 2011). Metacognitive prompts were used more often in the included studies (e.g., Long & Aleven, 2017; Sonnenberg & Bannert, 2015), and we also identified several studies adopting prompts to support multiple SRL strategies (e.g., Bannert & Reimann, 2012; Boykin, Evmenova, Regan, & Mastropieri, 2019). Nine studies (12.33%) used video or notes, followed by a concept map used in two studies (2.74%) and a worked example in one study (1.37%). Thirteen studies (17.80%) adopted multiple triggers. For instance, both the integrated SRL tool and prompts were adopted by Shin and Song (2016) to provide support for students' thinking processes, including planning, implementation, and evaluation in a web-based learning environment.

4.3.2. Academic performance

Among 73 intervention studies, in 63.01% of studies ($n = 46$), the SRL intervention had positive effects on learners' academic performance. No intervention had a negative effect on learners' academic performance. Nonsignificant effects of SRL on learners' academic performance were found in 14 studies (19.18%). The other 13 studies (17.81%) witnessed mixed effects of SRL on learners' academic performance. For example, Bannert, Sonnenberg, Mengelkamp, and Pieger (2015) utilized students' self-directed metacognitive prompts to enhance learning in computer-based learning environments. Their results indicated that metacognitive prompts produced positive results on students' academic performance in regard to knowledge transfer, but no significant difference in recall and comprehension.

Among the 90 correlation studies, 36 studies (40.00%) demonstrated that SRL was positively correlated with students' academic performance. Nineteen studies (21.11%) discovered that SRL was not related to learners' academic performance. The other 35 correlational studies (38.89%) witnessed a mixed correlation of SRL with learners' academic performance. For instance, Lawanto, Santoso, Goodridge, and Lawanto (2014) investigated how learners' perception of course material regarding importance, utility, and interest was connected to their SRL skills and academic performance in a web-intensive learning environment. They found no significant positive correlation between overall SRL components and performance. However, a significant positive correlation between goal setting and performance was identified.

4.3.3. Learning context

In terms of the learning context, we found the majority of the included studies were conducted in online learning ($n = 139$, 85.28%). Twenty-four studies (14.72%) examined SRL and academic performance in blended learning. Previous literature demonstrated that SRL strategies can have an impact on students' academic performance in both online and blended contexts (Broadbent, 2017). Our findings that most of the included SRL studies were conducted online suggest that formal educational systems are putting more emphasis on online learning. However, numerous studies proved that online learning cannot replace traditional learning completely, and both learning formats have their pros and cons (e.g., Condie & Livingston, 2007; Hannay & Newvine, 2006; Thorne, 2003). Future research should further explore SRL strategies in blended learning environments.

5. Conclusion and future research

Online and blended education has transformed the way people learn in the 21st century. In particular, the COVID-19 pandemic has accelerated the adoption of online and blended education around the world, not only for learners in higher education but also for learners in K-12 education. Given that the emotional and self-regulation skills of children and youth tend to be less developed or advanced than those of adult learners, SRL theories and research that use a developmental lens or framework will be important to account for the developmental needs of learners across childhood, adolescence, and adulthood. Our scoping review highlights the fact that the majority of studies on online or blended education from the pre-COVID era focused on higher education with adult learners (71.17%). However, during the COVID-19 pandemic, millions of children and youth worldwide experienced school closures and rapid shifts to online and blended education. Thus, there is an urgent need for research on children's and adolescents' self-regulated learning strategies in online learning contexts.

Furthermore, our scoping review points to a major gap in the literature on cognitive and emotion regulation strategies in online learning contexts. In fact, less than one percent of the research in our scoping review focused on emotion regulation strategies. However, a sizable body of research shows that children's and youth's attentional and emotional regulation skills contribute to their academic engagement and achievement in the classroom and at school (e.g., Liew, Valiente, Hernández, & Abrera, 2019). Given this, the time is ripe for researchers to address the gap in the scientific literature on K-12 learners and cognitive and emotion regulation strategies in online learning contexts in the post-COVID era. As mentioned earlier, there is also a need in the SRL literature to integrate theory and research that accounts for the development of attentional and emotional regulation and SRL skills among learners across childhood, adolescence, and adulthood.

The preparatory and planning phases include task definitions, goal setting, and planning (Pintrich, 2000, ; Winne & Hadwin, 1998), and a sizable body of research demonstrates that the preparatory SRL processes such as goal setting and planning contribute to self-efficacy and goal attainment in traditional learning environments, but also in MOOCs (e.g., Kizilcec et al., 2017). Yet, our scoping review revealed that only four studies (2.45%) from the pre-COVID era focused on the preparatory and planning phases of SRL in

online and blended environments. Without a clear intention and direction from the start, learners may easily flounder, lose motivation, and give up in online or blended learning environments. Thus, the preparatory and planning phases of SRL are important for learning and academic performance and deserve much more attention in future research. Furthermore, in the process model of emotion regulation (Gross, 1998) and the integrated model of emotion regulation in achievement situations (ERAS; Harley Pekrun, Taxer, & Gross, 2019), one of the strategies for regulating emotions in online or blended learning environments is situation selection, which involves proactive selection, avoidance, or change of the learning context, activities, and process which could then alter the emotions, motivation, and learning outcomes. This has implications for practice in that students can be supported to practice self-determination by being proactive rather than reactive in their learning. Instructors and parents can encourage students to engage in self-determined practices in their online education. Instructors could structure learning activities to provide students with greater choice and selection and then prompt students to be mindful or planful in choosing what, when, and how they would learn in their courses in order to facilitate students' autonomous (i.e., identified or intrinsic) motivation.

In conclusion, as online and blended learning increasingly become integral in formal, K-12 as well as higher education systems, diversity in learner characteristics (e.g., individual differences) and diversity in the modes of online instructional delivery also become key areas for research to ensure educational excellence, educational equity, and excellence for all learners. For example, our scoping review indicates that integrated SRL tools, scaffolds, and interventions offer diverse ways to support students' learning needs. Understanding the goodness of fit or match between the learner's characteristics and the characteristics of their learning contexts is important for academic emotions, motivation, engagement, and deep learning (Liew et al., 2019; Webster & Hadwin, 2015). In the post-COVID era, there is no turning back on the integration of online and blended learning in K-12 and higher education (Hodges et al., 2020). To effectively move forward and leverage the best that online and blended education can offer to learners, we need quality and systematic research to inform instructional design and approaches. We hope the findings from this scoping review will help synthesize as well as highlight gaps in the literature to provide guidance and direction on areas that require increased attention for further research.

Statement on conflicts of interest

We declare that we have no conflicts of interest.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.edurev.2023.100510.

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