A Meta-Analysis of Self-Regulated Learning Interventions Studies on Learning Outcomes in Online and Blended Environments

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Abstract

Self-regulated learning interventions influence students' learning outcomes in online and blended environments. A review of the literature about self-regulated learning strategies reveals both significant and non-significant effects on learning outcomes in online and blended environments. The aim of this study was to calculate the common effect size of empirical studies conducted between 2017 and 2022 that investigated the effect of self-regulated learning strategies on learning outcomes in online and blended environments, and to determine whether the common effect size shows a significant difference in terms of course type, self-regulated learning strategy type, school level, and learning context. A meta-analytical review method was employed to combine the outcome of independent empirical studies. The studies included in this review were collected from Scopus, IEEE Explore, and ERIC databases. A total of 15 studies were included in this study. Cohen's d coefficient was calculated for the effect size in this study. As the heterogeneity among the effect sizes of the studies was high ($Q > \chi^2$, $p < .05$), the common effect size was calculated following the random effects model. As a result of the meta-analysis, it was decided that self-regulated learning strategies had a "moderate" effect ($Q = 0.65$) on learning outcomes in online and blended environments. Moreover, the calculated common effect size showed no significant difference according to the type of self-regulated learning strategy, course type, school level, and learning context.

Keywords: Blended learning, online environments, learning outcomes, online learning, self-Regulated learning

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Both scientific understanding and technological advancement are progressing at breakneck speeds in today's world, creating an environment where students must adapt and learn independently to keep up with these rapid changes. As a result, they must develop the habit of independent study. Students who can self-regulate their learning do so because they are aware of what and how they have learned and their gaps in knowledge and abilities. As a result, students do better in school (Baker et al., 2019) and develop the habits necessary to continue learning throughout their lives. "Self-regulated," in this context, refers to the level of control an individual exerts over their thoughts, feelings, and actions to achieve a desired outcome (Lanaj et al., 2019). Self-regulated is the act of guiding and controlling one's actions (Karekla et al., 2019).

Blended or online learning can be an advantage for students to explore their knowledge by various methods (Alexa et al., 2022). Blended or online learning is learning that can emphasize the student's understanding of the material with several techniques, namely video learning, virtual learning, and others (Venkatesh et al., 2020). The characteristics of this learning can be used by students to learn independently because, in that learning, students can research to solve their problems before discussing or asking other people, including teachers (Rizaldi & Fatimah, 2020).

Albert Bandura and Dale Schunk are just two of the academics who have studied self-regulation since the 1980s (Elcin & Şahinkarakaş, 2021). According to this school of thought, people learn from their own experiences and by seeing and mimicking the actions that earn them positive and negative reinforcement (Bandura, 2021). This strategy involves focusing on the behavior, remembering it, being open to contemplating it and, finally, acting on what one has contemplated (Hensley, 2020). During this process, people can monitor their habits, evaluate them using their standards, and adjust their conduct accordingly (Dontre, 2021). A growing body of research on student self-regulation in the classroom has led to the development of self-regulated learning (Chumbley et al., 2018).

Self-regulated learning (SRL) occurs when an individual chooses their learning goals, regulates their attention, interest, and effort, and is directed and constrained by their own objectives and the features of their immediate environment (McCardle et al., 2019). As a result, they develop a sense of self-awareness, sagacity, and educational agency (Suleman et al., 2020). Students' efforts to better understand themselves are linked to developing metacognitive abilities, integrating new information with existing knowledge, cultivating intrinsic motivation, and acquiring practical environmental management skills. Hence, the four sub-categories of the self-regulated learning model are: cognitive, metacognitive, resource management, and motivational techniques (Koivuniemi et al., 2021).

Students' cognitive strategies encompass the actions and mental processes they apply when studying to accomplish a goal or complete a task related to a specific academic topic (Teng, 2020). Rehearsal, elaboration, and organizing are all examples of cognitive techniques (Zheng & Zhang, 2020). Predicting, planning, monitoring, and evaluating are all examples of the metacognitive procedures that assist people in managing their thought processes (Teng et al., 2022). Strategies for managing one's resources include organizing and prioritizing one's time and studying space, putting forth the consistent effort, collaborating with one's peers, and asking for assistance when stuck (Bergmark, 2020). The final component of self-regulated learning is motivational methods, which address students' intrinsic values, sense of competence, and test-taking anxiety (Fukuda, 2022).

Self-regulated learning plays a crucial role in determining learning outcomes in the context of online education (Jin et al., 2023). Students' ability to watch, control, and regulate cognitive processes, motivation, and behavior has a significant impact on their success in online learning environments. In online environments, where students often have greater autonomy and flexibility, they will excel. SRL strategies and supportive online behaviors mediate achievement, goal orientation, and academic

expectations (Yeh et al., 2019). To thrive in online courses, it is important to set goals, plan learning strategies, and monitor one's own progress, as students with these skills are more likely to remain engaged and persist in their online courses (Martin et al., 2022). Additionally, self-regulated students are better prepared to adapt to various challenges in online learning, such as effective time management, dealing with distractions, and seeking help when needed. Therefore, developing self-regulated skills becomes a crucial design aspect of online learning experiences, ultimately impacting student success and satisfaction in the digital education landscape. Overall, self-regulated learning plays a critical role in the success and adaptability of learners in the online learning environment (Zhang et al., 2023).

In blended learning, where traditional face-to-face instruction is integrated with online components, self-regulated learning continues to have a significant influence on learning outcomes (Morris, 2019). The hybrid nature of blended learning demands a certain level of autonomy from students as they navigate face-to-face and virtual environments. Individuals who possess strong self-regulation skills, including goal setting, time management, and metacognitive awareness, are better positioned to leverage the advantages of blended learning. This includes effectively using online resources, engaging in collaborative activities, and adapting to diverse teaching modalities. Students with strong self-regulated learning abilities are more likely to feel ownership of their learning experiences, transition smoothly between face-to-face and online components, and thus enhance their overall academic achievements in blended learning environments (Kintu et al., 2017). Therefore, fostering self-regulated learning becomes an integral component in optimizing the effectiveness and success of the blended learning model.

Globally, numerous academics have explored the idea of self-regulated learning through a wide variety of variables. Multiple studies have found that students' academic success is enhanced when they exercise self-control over their studying (Perry et al., 2018). Meta-analyses of self-regulated learning are few and can only be found in academic journals published in other languages. There is some evidence from meta-analyses to suggest that using self-regulated learning strategies has a positive effect (d= 0.50-0.80) on students' motivation, reading comprehension, and overall academic achievement (Theobald, 2021).

While there has been much primary research on self-regulated learning, the results need to be more consistent. Therefore, a meta-analysis of this research is necessary for more definitive findings. The purpose of this study is twofold: to quantify the size of the effect of studies that have looked at the impact of self-regulated learning on learning outcomes and to see whether self-regulated learning strategies vary significantly across course content, grade level, and learning environment. The purpose of this meta-analysis is to provide a foundation for further studies of self-regulated learning.

This study looked at how various types of self-regulated learning strategies, levels of education, research methodologies, and types of courses can moderate the positive impact of self-regulated learning on student learning outcomes. It is generally agreed that practitioners must know which self-regulated learning method works best for which grade level and which subject to best support students in achieving their academic goals (teachers or academicians). Equally important is finding out how different types of research studies affect students' performance in the classroom, as this will direct future studies. In this context, the following questions were considered:

1. What is the overall effect of SRL interventions on learning outcomes in online and blended environments?

2. Does the effect of SRL interventions on learning outcomes in online and blended environments show a significant difference according to SRL strategies, course type, learning context and school

level?

Literature Review

Self-Regulated Learning

Controlling and directing one's efforts to complete challenging learning activities is what self-regulated learning (SRL) is all about (Lemmetty & Collin, 2020). Using the iterative SRL process, students can track their progress in metacognition, cognition, motivation, and behavior (Järvelä et al., 2020). SRL has been conceptualized in various theoretical models and frameworks (Cuyvers et al., 2020). Some SRL models have four components (Du & Hew, 2022), but most can be broken down into three (preparation, performance, and evaluation).

Learners use many SRL tactics during these stages. The current study's SRL strategies were primarily categorized using Pintrich's (Cervin-Ellqvist et al., 2021) conceptual and operational framework, one of the most influential models in this field and containing the most extensive SRL strategies (Li, 2019). We began by classifying SRL methods into three categories: cognitive, metacognitive, and resource management (Callan et al., 2022). Students' cognitive methods include mental rehearsal, in-depth thought, and critical analysis as they engage in academic work. Planning, monitoring, and regulating are all examples of metacognitive practices that help students become more self-aware and in charge of their learning. Strategies for managing and regulating resources include managing time and the environment, controlling one's effort or motivation, asking for aid, and learning from one's peers. We included emotional regulation as a fourth type of SRL technique since it is an integral part of SRL processes (Ben-Eliyahu, 2019).

Many empirical investigations (Thomas et al., 2019) have shown favorable correlations between SRL and academic success. Academically successful students tend to make better use of SRL methods (Broadbent & Fuller-Tyszkiewicz, 2018). Learners who take responsibility for their education are more likely to use effective cognitive techniques, leading to more impressive academic growth (Altan et al., 2019). The effectiveness of students' metacognitive methods is also strongly connected to their grades (Chytrý et al., 2020).

SRL Interventions Online or Blended Learning Environments

Interventions to aid students' self-regulated learning (SRL), particularly in virtual classrooms, have garnered a lot of attention because of SRL's positive impact on students' ability to learn. Students in online classrooms have greater access to materials and possibilities for collaboration than their counterparts in traditional classroom settings (Gupta & Pathania, 2021). Online education expands access for students who might otherwise need help attending traditional classes due to their busy schedules (Ramírez-Hurtado et al., 2021). Additionally, online education often transfers power from traditional educational institutions to solitary students (Sadeghi, 2019). Students motivated to learn independently will have higher success in online courses (Rahiem, 2021).

It has been proven that students' SRL can be encouraged in an online classroom. The usage of digital assets can aid SRL in many ways. Huang & Lajoie (2021) created a digital training package to help students effectively implement SRL methods in their STEM classes. Students had to read and perform exercises as part of the Science of Learning to Learn training incorporated into the course learning system site to gain exposure to and practice SRL methods in the context of STEM subjects.

Supporting students' ability to SRL may be facilitated by computer-based scaffolds that offer continuous diagnostics and calibration, and dynamic support (Lim et al., 2023). In the study conducted by du Boulay (2019), students engaged in SRL in a hypermedia environment where human tutors offered adaptive scaffolding to help students organize, monitor, and evaluate their learning. Ten domain-specific learning objectives were offered to students in the fixed scaffolding condition. Prompts are another potential SRL intervention. The questions and suggestions modeled effective metacognitive and cognitive strategies for online learning (Wong et al., 2019).

SRL interventions vary in their ability to boost student performance (Núñez et al., 2022). There has been minimal debate regarding what makes SRL interventions effective in online or mixed learning environments, despite researchers having discovered various features that modulate the their effectiveness (Lane & D'Mello, 2019). As such, the current meta-analysis also looks to explore aspects of SRL interventions in different kinds of educational settings.

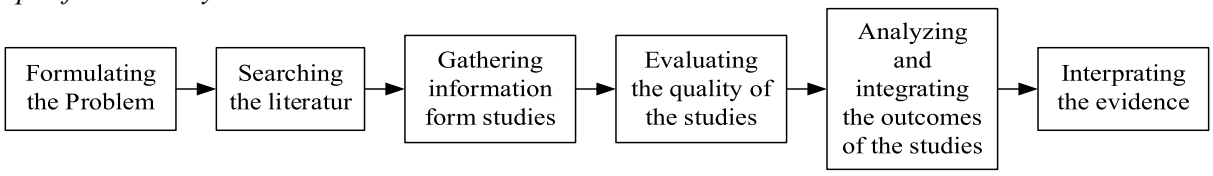
Method

Research Design

This study used a meta-analysis approach to investigate the effect of self-regulated learning on learning outcomes (Panadero et al., 2017). Meta-analysis, which involves combining the findings of multiple research, consists of the following steps Figure 1 (Cooper, 2015):

Figure 1

Steps of Meta-analysis



Undertaking a meta-analysis as per the structured approach delineated by Cooper (2015) involves a systematic progression through six essential stages. The first step encompasses formulating the problem, requiring a precise definition and articulation of the research question or issue at hand. Subsequently, the literature search becomes pivotal as the second stage, involving a comprehensive exploration of existing studies to ensure an exhaustive understanding of the subject matter. Moving forward, the third stage involves the meticulous gathering of information from selected studies and combining relevant data for later analysis. Quality assessment of the chosen studies is undertaken in the fourth stage, critically evaluating their rigor and reliability. The fifth stage involves the analytical synthesis and integration of outcomes derived from the selected studies, using statistical methods to distill meaningful patterns and insights. Finally, the sixth stage is dedicated to the interpretation of the evidence, where synthesized findings are contextualized and translated into meaningful conclusions. This sequential progression through the six stages of meta-analysis ensures a methodical and rigorous approach to distilling knowledge from a diverse range of studies, contributing to a nuanced and comprehensive understanding of the researched phenomenon.

Literature Search Procedure

This study included studies collected from Scopus, IEEE Explore, and ERIC databases. The database search was conducted between January 2023 and February 2023. These search terms were entered in both English and French during the search: "self-regulated learning" OR "self-regulated learning intervention on learning outcomes" AND "online learning" OR "blended learning." The report also details that the

collected papers were searched for further relevant literature. The research on the impact of self-regulated learning on learning outcomes collected a total of 513 studies. After restricting the subjects and objects of research, 15 studies remained.

The didactic method is used to analyze the selected journals by applying meta-analysis related to SRL following the previously described criteria. This didactic method involves systematic steps to compile, organize, and analyze relevant data from the selected journals (Tejedor et al., 2019). First, journals that met the inclusion criteria were carefully selected based on the topic of SRL, reliability, and relevance. Subsequently, relevant data from these journals were extracted and coded according to predetermined variables, such as the observed types of SRL strategies, level of education, and learning context. Then, meta-analysis was conducted to combine the findings from the selected journals and generate integrated effect estimates. This analysis enabled us to statistically conclude the relationship between SRL and learning outcomes in online and blended environments. By using the didactic method, we can gain a deep understanding of the role of SRL in the learning context and provide valuable insights for the development of self-regulated education.

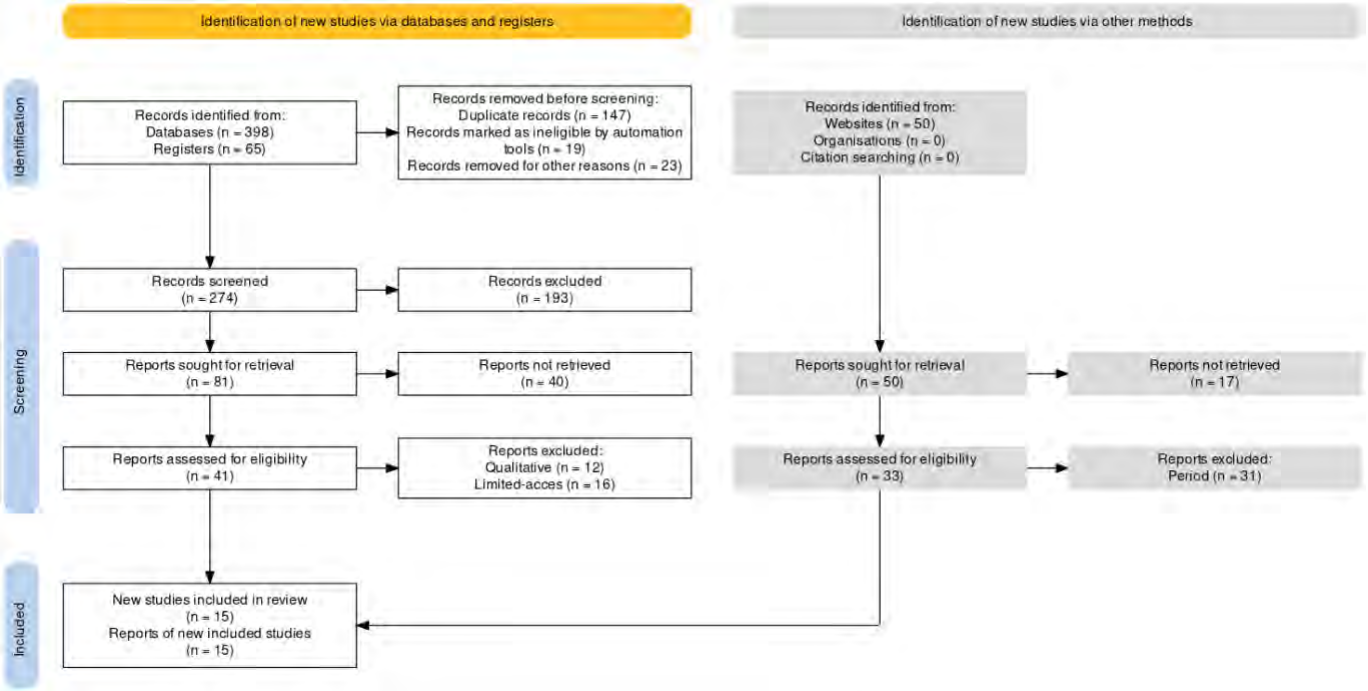
Study Inclusion and Exclusion Criteria

In this study, we looked at quantitative research conducted between 2017 and 2022 that assessed the impact of self-regulated learning on learning outcomes. These were the conditions for inclusion: *(i)* an article using an empirical approach that was published between 2017 and 2022. *(ii)* We are compelled to investigate how self-regulated education influences student performance. *(iii)* Both empirical and relational research require a sample size *(N),* mean score *(X),* and standard deviation.

Using the above criteria, we identified 398 studies and screened 274 of them. Ultimately, 15 studies were included after reviewing reports sought for retrieval and assessing their eligibility. These studies examined the effect of self-regulated learning on learning outcomes or its association with learning outcomes. Figure 2 shows an outline of the steps needed using the PRISMA protocol by adopting Page et al. (2021) to include the papers found in the literature review in the meta-analysis.

Figure 2

Flowchart of Inclusion and Exclusion of Studies



Referring to the coding template used in the systematic review and coding general information for all 513 studies, fifteen eligible studies were identified through the screening process. By discussing discrepancies, the authors and coders resolved those differences and modified the original coding scheme. Finally, the authors also validated the coding of 50 articles with new studies via other methods using a more established coding scheme. Specifically, we extracted information about the authors, year of publication, course type, self-regulated learning strategy, learning context, as well as the level of education and number of research subjects. Information was collected regarding the sources and perspectives of learning from the coding scheme used in the included studies.

As a first step, we filtered and identified coding indicators related to self-regulated learning strategy and learning context from the existing coding scheme based on two principles proposed in both online learning and blended learning. Subsequently, an analysis was conducted regarding specific educational levels presented and the year of publication. Finally, according to data processing, empirical data were selected, particularly from non-limited access journals. This categorization was performed to investigate the influence of self-regulated learning strategies on learning outcomes in online and blended environments, as well as to explore significant differences in terms of course types, types of self-regulated learning strategies, school levels, and learning contexts.

Codes for Self-Regulated Learning

In this analysis, we employed a coding scheme including four primary strategies (metacognitive, motivational, cognitive, and mixed) to examine self-regulated learning (SRL) within the contexts of online learning (OL) and blended learning (BL). In this analysis, we employed a coding scheme including four primary strategies (metacognitive, motivational, cognitive, and mixed) to examine self-regulated learning (SRL) within the contexts of online learning (OL) and blended learning (BL). Specifically, online learning involves the delivery of instruction through electronic means, which requires students to utilize self-regulated learning strategies to effectively engage with a range of multimedia tools, internet platforms, and applications (Maddison et al., 2017).

In the metacognitive (Me) dimension, our analysis focused on strategies such as self-monitoring, learning planning, reflection, and goal setting utilized by students (Altıok et al., 2019). These processes are vital in self-regulated learning, enabling students to watch progress, set goals, plan study activities, and engage in reflection for improved understanding and performance. Examining these strategies provided insights into cognitive and metacognitive processes, enhancing our understanding of effective learning strategies and interventions in educational settings.

In the motivational (Mo) dimension, we focused on intrinsic and extrinsic motivation, interests, and relevant values within the learning context (Sahade et al., 2022). Understanding these factors is crucial for promoting effective self-regulated learning, as they affect student engagement and persistence. By exploring the interplay between intrinsic and extrinsic motivation and considering self-confidence, interests, and values, we inform instructional strategies that enhance motivation and create a positive learning environment. Our examination of these motivational aspects contributes to understanding the factors influencing self-regulated learning and promoting student motivation and engagement.

In the cognitive (Co) dimension, we analyzed the strategies and cognitive skills used by students in information processing, concept acquisition, and problem-solving (Scherer & Beckmann, 2014). Through this analysis, we gained insights into how students engage with and understand learning materials. This involved examining codes related to time management, information organization, and the effective implementation of learning strategies. By exploring these aspects within the Co dimension, we contribute to understanding the cognitive factors that influence self-regulated learning and inform instructional practices for promoting effective cognitive engagement and mastery of content.

In the mixed (Mx) dimension, we examined the interplay among the metacognitive, motivational, and cognitive dimensions. By exploring diverse subjects and educational levels, we aimed to understand how these dimensions interact in SRL. This holistic approach identified commonalities and variations in self-regulated learning processes, providing insights for educators and researchers. We saw the interplay among these dimensions and sought patterns of findings across diverse subjects (language (Lag), social science (SoSc), science (Sc)) and educational levels (primary (Prm), secondary (Sec), high school (HS), undergraduate (Und)). By employing this coding scheme, we were able to systematically investigate the impact of self-regulated learning in OL and BL within various educational contexts.

Data Analytic Strategy

Cohen's effect size measure, which is the standardized mean difference, was used in this study. The standard deviation is divided by the difference between the raw means to get Cohen's d. As stated by Cohen et al. 80 (2013), 'no effect' represents a d-value of less than 0.20, 'low' if the d-value is between 0.20 and 0.50, 'moderate' if between 0.50 and 0.80, and 'large' if more than 0.80.

The meta-analysis approach involved calculating a combined effect size by first adding up the effect sizes from separate studies. Both the fixed and random effects models were used to derive the average effect size. Amidst the debate over which model to employ, two options present themselves: The first is a check for diversity, which shows how much the measured difference in effect sizes (Q) differs from the difference caused by sampling error (Cooper, 2015). The second is to assess the consistency of effect sizes across studies to determine whether the fixed effects or random effects model is more appropriate.

Based on the analysis of the effect sizes, the Q-value needed to be decided and compared to the value of the degree of freedom (df=n-1) in the χ^2 table. If $Q < \chi^2$ *(p > .05)*, effect size in different studies is thought to be the same, so the fixed effects model is used to put them all together. In the case that $Q > \chi^2$

(p < .05), the effect size is heterogeneous, and the random effects model is used instead. The researcher's needs in this study are better served by the random effects model. However, a heterogeneity test was conducted because the aim of this meta-analysis is to generalize the findings to a broader context, and a literature review was used to identify the original studies.

The studies used here can be broken down into distinct subgroups. Some of these studies reported on the cumulative impact of self-regulated learning on achievement, while others looked at the impact of self-regulated learning strategies in isolation, whether they be cognitive, metacognitive, mixed, or motivational. Because of this, the studies should be treated as wholes rather than as parts when doing analyses. Studies that reported solely the combined effect were disregarded. The common impact size was also compared among subgroups to see if there was a statistically significant difference between the various forms of self-regulated learning strategies. In addition, a categorical moderator analysis was used to see if there was a statistically significant difference in the effect size of self-regulated learning on learning outcomes across course type, school level, and learning setting. Under the random effects model, the significance level of the $Q_{between}$ value was used to assess the moderator's role. Publication bias and its implications were investigated using moderator analysis, a funnel plot, and the Egger's Regression Intercept test. Data analysis was performed using JASP.

Results

A total of 5519 participants sampled from the empirical research were included in this analysis. Table 1 provides summary statistics and study characteristics for all included studies in the meta-analysis.

Table 1

Substantive Features of the Included Studies

Study ID	APA Citation	Course type	Learning Context	SRL Strategies	N	School level	ES	SE
1	Song & Kim (2021)	Lag	OL	Me	56	Und	0.41	0.14
2	Ariel & Karpicke (2018)	SoSc	OL	Me	60	Und	0.87	0.13
3	He (2022)	Sc	OL	Mx	370	HS	0.80	0.05
4	Anthonysamy (2020)	Lag	BL	Mx	563	HS	0.15	0.04
5	Anthonysamy (2021)	Sc	BL	Mx	563	Und	0.15	0.04
6	Khurshid (2020)	SoSc	OL	Mo	28	Und	0.34	0.20
7	Özdal (2022)	Lag	OL	Mo	384	Und	0.20	0.05

8	Karacan (2022)	Lag	OL	Mo	112	Und	0.56	0.10
9	Hong (2021)	SoSc	OL	Mo	541	Und	0.77	0.04
10	Wan Yunus (2021)	SoSc	OL	Co	40	Prm	0.50	0.16
11	Boykin (2019)	Sc	OL	Mx	69	Prm	1.32	0.12
12	García Botero (2021)	Lag	OL	Mx	52	HS	0.84	0.14
13	Cai (2020)	SoSc	OL	Mx	2536	Sec	0.71	0.02
14	van Alten (2020)	SoSc	BL	Mx	115	Sec	0.51	0.09
15	Lai (2018)	Sc	OL	Mx	30	Prm	1.82	0.19

Table 1 shows 15 articles sampled for detailed analysis related to the type of subject, self-regulated learning strategies, school level, and learning context. The effect size obtained from all articles had an average of 0.66 and the standard error has an average of 0.098. These results will be analyzed again through Table 2.

Table 2

Subgroup Analysis

Grouping Factor	Subgroup	Frequency	Percentage
Course Type	Lag	5	33.3%
	SoSc	6	40%
	Sc	4	26.7%
Self-regulated Learning Strategies	Co	1	6.67%
	Me	2	13,3%
	Mx	8	53.3%
	Mo	4	26,7%
School Level	Prm	3	20%
	Sec	2	13.3%
	HS	3	20%
	Und	7	46.7%
Learning Context	OL	12	80%
	BL	3	20%

Table 2 shows that out of all the fields of study, 33.3% (f=5) were devoted to linguistics, 40% (f=6) to the social sciences, and 26.7% (f=4) to the natural sciences. There was a significant difference between the types of strategies used for self-regulated learning: 6.67% (f=1) of the methods were cognitive, 13.3% (f=2) were metacognitive, 53.3% (f=8) were mixed, and 26.7% (f=4) were motivational. Twenty percent (f=3) took place in elementary schools, 13.3 percent (f=2) in junior highs, 20 percent (f=3) in high schools, 46.7 percent (f=7) in colleges and universities. Eighty percent (f=12) of the studies cited online learning as the context for learning, while twenty percent (f=3) cited blended learning.

The purpose of the moderator analysis was to consider any distinguishing factors between course type, self-regulated learning approach, and learning context on the impact of self-regulated learning on learning outcomes. Table 3 displays the outcomes of the moderator analysis.

Table 3

Moderator Analysis

Moderator Name	Heterogeneity			
	Qw	Qb	df	p
Course Type	257.12	173.87	2	1.75
Lag				
SoSc				
Sc				
Self-regulated Learning Strategies	427.9	3.098	3	0.21
Co				
Me				
Mx				
Mo				
School Level	303.36	161.69	3	7.90
Prm				
Sec				
HS				
Und				
Learning Context	196.60	234.39	1	6.55
OL				
BL				

Table 3 shows that no statistically significant variation exists in impact size across groups defined by course type, self-regulated approach, school level, and learning setting *(Qb< $\chi 2$; p>.05).* In other words, little difference is demonstrated between the language, social studies, and science classes where self-regulated learning happens. Neither cognitive, metacognitive, mixed, nor motivational strategies differentiate in students' ability to improve learning self-regulation. The average effect size of the research comparing online and blended learning in elementary, secondary, and university settings also indicates no statistically significant difference.

One of the best ways to summarize the findings of a meta-analysis is via a forest plot. This review includes 15 studies, and their combined meta-analysis results are displayed in the following forest

plot:

Figure 3

Forest Plot of Meta-analysis Results

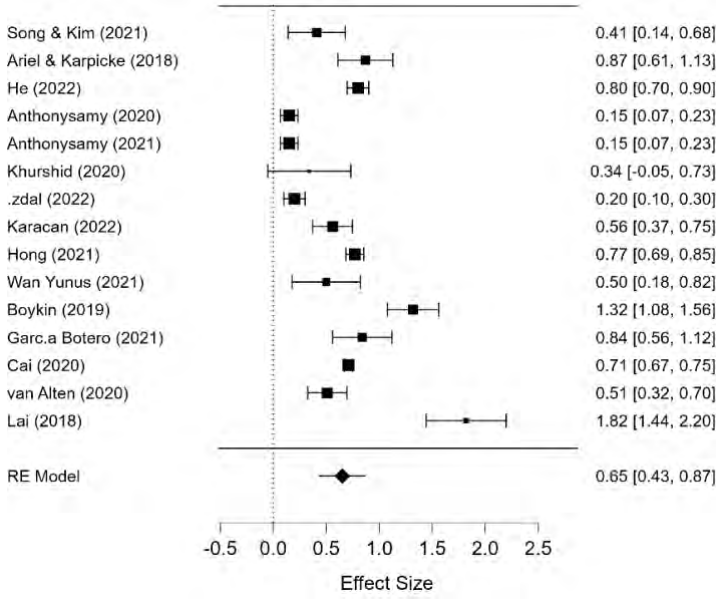


Figure 3 shows that a random effects model (RE Model) with a value of 0.65 was found. This means that self-regulated learning intervention studies affect learning results in online and blended environments by 65%, while other factors account for the remaining 35%. According to Cohen et al. (2013), five of these studies had a 'low' effect size, nine had a 'moderate' effect size, and seven had a 'large' effect size.

If the average effect of each study does not show substantial variation, this could be a sign of press bias. To do this, a moderator analysis was done. Using a random effects model, it was found that the effect of self-regulated learning on learning outcomes remains relatively consistent regardless of the author of the study. Additionally, a funnel plot can reveal bias in the reporting of results. If there is no publication bias, the effect sizes of the included studies will be symmetrically distributed around the average effect size in the funnel plot. In the presence of publication bias, the effect sizes will be concentrated towards the middle or the bottom of the plot. Figure 4 shows the study's funnel plot.

Figure 4

Funnel Plot of Publication Bias

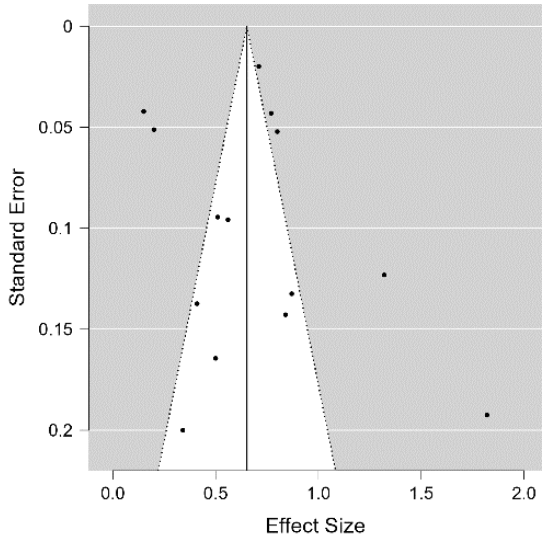


Figure 4 shows that direct funnel plots cannot be used to assess whether or not the funnel is symmetrical, highlighting the requirement for the results of Egger's Regression Intercept test. Egger's regression intercept test yielded a value of 0.691 for the intercept. These findings suggest that publication bias is unlikely to account for the observed consistency in impact size across studies.

Discussion

The results of this meta-analysis study show that most of the self-regulated learning seen from online learning has a percentage of 80%, and in the random effect model obtained 0.65, which means that the effect of self-regulated learning in intervening with students to improve learning outcomes is still at the "moderate" level ($Q = 0.65$). The results of heterogeneity show that self-regulated learning strategies have better results than course types, school levels, and learning contexts, meaning that the strategies of SRL are indeed very decisive for the results of learning outcomes obtained by students, so that the determination of these strategies is very influential in improving learning outcomes in learning.

The results are supported by Machmud & Ramadhan (2022) who conducted a meta-analysis on the effect of self-regulated learning practices on learning outcomes. Additionally, Panadero et al. (2017) found that the choice of self-regulated learning procedures has a significant impact on the effect size observed in enhancing learning outcomes. Although the effect is still considered moderate, SRL strategies can decide good results in improving learning outcomes that can be obtained by students, which further explains that the provision of online learning by considering SRL strategies understands the learning outcomes obtained by each student.

This meta-analysis provides new evidence that SRL strategies influence learning outcomes because many of the interventions use a combination of cognitive and metacognitive strategies, as well as cognitive and motivational and metacognitive with motivational components. This is supported by the fact that $Q_b = 3.098$ and $Q_w = 427.9$. These findings prove that SRL practices can have a positive effect on students' final grades.

The resulting data does not show bias, meaning that the data analyzed is symmetrical and meets the adequacy criteria. Although the results show no significant difference in the between-group effect *(Qb< χ2; p >.05),* this indicates that improvements in learning outcomes may be influenced by factors other than SRL. However, among all the factors studied in relation to learning outcomes, SRL strategies proved to be the most influential. The use of SRL interventions with a well-integrated mix of

metacognitive, cognitive, and motivational components had the greatest impact.

This study, revealing a moderate effect of self-regulated learning strategies on learning outcomes in online and blended environments with no significant differences based on various factors, forms a solid foundation for understanding the broad implications of such strategies. In contrast, Jansen's (2019) study suggests that while SRL interventions were effective, moderators failed to explain significant variance in effect sizes, indicating a need to delve deeper into the conditions influencing the efficacy of these strategies. Vaculíková's (2018) While this study provides a comprehensive overview, these other studies offer nuanced insights into specific interventions, contextual factors, and learner characteristics, collectively contributing to a more holistic understanding of optimizing SRL in diverse educational settings. Meanwhile, Theobald's (2021) findings highlight the relevance of course design characteristics and feedback, factors not explicitly explored in this study. The research of Dent and Koenka (2016) emphasizes the importance of considering specific factors such as process, academic subject, and grade level, offering additional dimensions for exploration. As a recommendation for further research, a comprehensive investigation into the role of moderators, an exploration of the challenges in explaining successful learning, and a focus on the impact of feedback and course design characteristics could enhance the understanding of self-regulated learning strategies in diverse educational settings. Integrating these insights could contribute to a more nuanced and comprehensive framework for the application of self-regulated learning strategies.

In the realm of self-regulated learning (SRL), this meta-analysis sheds light on the overall impact of SRL strategies in online and blended learning environments. It reveals a moderate effect on learning outcomes without significant variations based on strategy type, course format, school level, or learning context. In contrast, Rako et al.'s (2014) empirical research focuses on the application of prompts and learning analytics to support SRL in blended learning, anticipating differences in student engagement, formative assessment outcomes, and overall satisfaction. Sutarni's study (2021) highlights the role of SRL in optimizing the digital learning environment and fostering academic achievement. Vanslambrouck's findings (2019) emphasize the predictive nature of achievement motivation on SRL profiles, offering recommendations for educational practice. Broadbent & Fuller-Tyszkiewicz investigation (2018) identifies learner profiles associated with academic success, emphasizing the importance of addressing anxiety alongside high motivation and strategy adoption. While this study provides a comprehensive overview, these other studies offer nuanced insights into specific interventions, contextual factors, and learner characteristics, collectively contributing to a more holistic understanding of optimizing SRL in diverse educational settings.

This study's findings suggest that there is a considerable variation across SRL tactics, course types, learning contexts, and syllabi when it comes to the impact of SRL interventions on learning outcomes in online and mixed settings. These results highlight the need of giving students structured guidance on how to regulate their learning processes successfully through the provision of explicit teaching on SRL methods, which has been shown to have a favorable effect on learning outcomes. The study also shows that the impact of SRL interventions varies depending on the course format, with blended courses possibly providing more opportunity for face-to-face engagement and collaborative learning than entirely online courses. The success of SRL interventions may also depend on factors in the learning setting, such as the accessibility of supplementary materials and technical infrastructure. Finally, it was discovered that elementary, middle, and high school pupils respond differently to SRL interventions. These findings emphasize the necessity for individualized SRL interventions to maximize learning outcomes in online and mixed settings by considering specific SRL tactics, course types, learning contexts, and school levels.

Conclusions and Suggestions

In conclusion, the meta-analysis sheds light on the moderate yet consistent impact of SRL interventions on learning outcomes in online and blended environments. The findings emphasize the pivotal role of SRL strategies, surpassing the influence of course types, learning contexts, and school levels. The combination of cognitive, metacognitive, and motivational components in SRL interventions proves crucial for enhancing students' final grades. Despite the robustness of the study, several avenues for future research can be identified. A more profound exploration into moderators influence on the efficacy of SRL strategies is called for, considering variables like individual differences and technological affordances. Investigating challenges in explaining successful learning beyond SRL, including feedback mechanisms and course design characteristics, promises to enrich our understanding. Moreover, acknowledging the differential responses of students at various educational levels calls for tailored and individualized SRL interventions. Future research endeavors should embrace longitudinal studies to gauge the sustained impact of SRL interventions over time, providing insights into their durability and factors influencing longevity. This study lays a foundation for a nuanced framework, and future research should build upon these findings to refine our understanding and guide evidence-based practices in the evolving landscape of digital education.

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