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Systematic Review

The Effects of Using Scaffolding in Online Learning: A Meta-Analysis

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Abstract: Scaffolding is widely used in online learning; however, it is unclear whether scaffolding can effectively enhance students' online learning performance. To evaluate its effectiveness, we conducted a meta-analysis that included 83 effects sizes from 32 articles published between 2011 and 2021. The findings demonstrated that scaffolding had a significant role in improving students' online learning performance with an overall effect size of 0.53. In addition, we analyzed the effects of five moderator variables to gain insights into how scaffolding affects students' online learning performance under different conditions. The discipline, learning outcome type, and scaffolding type were identified as significant moderators. It is expected that the research results will guide teachers to design online scaffolding strategies and improve students' online learning performance.

Keywords: scaffolding; online learning environment; meta-analysis; effect size

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1. Introduction

During the post-pandemic period, global education has been greatly impacted by online learning. It has come to light that online learning faces several problems, such as technology insufficiency [1], lack of social interaction [2], poor communication [3], etc. The quality of online learning has garnered increased attention from scholars who have attempted to improve it by incorporating various teaching methods or strategies [4].

One promising approach that has garnered considerable attention is scaffolding. Scaffolding strategy is considered an effective approach to improve online learners' performance. For example, Valencia-Vallejo, López-Vargas, and Sanabria-Rodríguez found that the motivating scaffolding is benefit of improving students' online learning performance [5]. Wang developed a web-based argumentation system that provides teachers with scaffolding for argument, and the result also showed a positive influence of scaffolding on students' learning effectiveness [6].

However, it is important to acknowledge that some studies suggest that the impact of scaffolding on online learning performance is marginal or negative. For example, Valle et al. discovered that using learning analysis dashboard to provide students with learning feedback has a negative impact on students' learning emotions [7]. Yu and Pan designed online prompts to assist students in learning and found that the scaffolding had minimal effect on improving students' online learning performance [8].

Given the divergent outcomes observed in previous research, it is crucial to establish a comprehensive understanding of the effect of scaffolding on students' online learning performance. In this study, we aim to explore whether and how scaffolding can improve students' online learning performance through a meta-analysis. There are mainly two research questions as follows. (1) What is the overall impact of scaffolding on students' online learning performance? (2) What are the potential variables that may influence the effect of scaffolding in an online learning environment?

By undertaking this study, our aim to address the existing gaps in the literature, contribute to the ongoing discourse on online learning, and ultimately offer evidence-based recommendations for instructional designers who aim to optimize the online learning experience of designing appropriate scaffolding.

2. Review Related Research

2.1. Scaffolding in Education: Theory and Applications in Online Learning

The term "scaffolding" originated in the construction field, referring to temporary structures that support buildings [9]. In education, scaffolding is primarily defined as providing appropriate assistance to learners, enabling them to solve challenging problems that they cannot tackle on their own [10,11]. Researchers attribute scaffolding to Vygotsky's Theory of Social Constructivism and the concept of the "Zone of Proximal Development" (ZPD) [12]. According to Vygotsky's Social Constructivism, interaction with teachers or peers can help learners reduce cognitive loads and facilitate cognitive processing [11]. This interaction is particularly beneficial for students to grasp new concepts within their Zone of Proximal Development. In the context of online learning, providing scaffolding support for learners, such as providing learning guidance, feedback, and assisting learners in communication and cooperation, etc., is useful for students to learn knowledge, and their learning satisfaction will be improved [13–15].

2.2. Meta-Analyses Related to Scaffolding in Online Learning

It is a widely held view that scaffolding contributes to learners' cognitive and non-cognitive development. For instance, scaffolding gives an impetus to students' cognitive development [5,16], affective development [17,18], and facilitates the development of metacognitive awareness [19,20]. What is more, with learning support, students can become more autonomous. Despite theoretical support, the research results on the impact of scaffolding on students' online learning performance are mixed. Therefore, some researchers try using a meta-analysis to integrate the findings of multiple studies to explore the impact of scaffolding on students' online learning performance [21,22].

An early review of scaffolding in online learning was conducted by Jumaat and Tasir [22]. They emphasized the positive significance of online scaffolding on learning reflection, active learning, and group cooperative learning, suggesting that scaffolding can help improve students' learning performance. They identified four main types of scaffolding in the online learning environment: procedural scaffolding (guide learners in using learning resources or providing guidance on tool usage), conceptual scaffolding (assisting learners in identifying what to learn, such as providing a knowledge outline that presents information and logical relationships between concepts), strategic scaffolding (providing alternative ways to complete tasks, and a well known example is creating forums to help learners to communicate and address issues), and metacognitive scaffolding (supporting learners in assessing their current learning level, for example, using quizzes to check the level of learners' knowledge).

A second meta-analysis was conducted by Doo et al., which compared online learning performance between scaffolding and non-scaffolding approaches, and it examined the impact of scaffolding design on students' online learning performance [21]. They found that scaffolding significantly improved online learners' learning performance (effect sizes ranged from 0.660 and 1.072). In addition, it was found that the type of scaffolding, source of scaffolding, learning outcomes, and disciplines context had a significant mediating effect on learning outcomes. These findings show that: (a) scaffolding can be a powerful medium to promote learners' online learning effect; and (b) scaffolding design plays a crucial role.

However, the above-mentioned meta-analyses were limited in some ways. Firstly, the review conducted by Jumaat and Tasir is a narrative review, which may be subjective to some extent, as it is written based on the author's viewpoints, knowledge, and experience, making it susceptible to author preference [22]. In addition, when the number of studies grows dramatically, to accurately synthesize the existing research results in narrative review is impossible. Secondly, existing research does not focus on the effect of scaffolding on online learning in primary and secondary schools [21,22]. Thirdly, the existing research conclusions may be subject to debate due to the great progress in technology in recent years, which may influence the effectiveness of scaffolding for online learning [21,22].

2.3. Moderating Factors Influencing the Effect of Scaffolding in Online Learning

At present, there is no conclusion about whether scaffolding can improve students' online learning performance. One possible reason is that scaffolding may play different roles in different online learning situations. It is necessary to investigate the variables that may moderate the effect of scaffolding in online learning.

Scaffolding may have different impacts on different disciplines. Lin et al. designed an adaptive guidance (meta-cognitive scaffolding) to help students learning computer knowledge and found that the scaffolding significantly improved students' learning effect [23]. Bannert and Mengelkamp used meta-cognitive scaffolding to assist students in learning psychological knowledge, but they found that scaffolding does not have a positive effect on knowledge learning [24]. Therefore, we can hypothesize that some disciplines may be more connected with scaffolding than other disciplines.

Another personal characteristic that can be used as the moderator of scaffolding effect in online learning is grade level. For example, to promote reading comprehension performance of primary school students, Chen developed an online collaborative reading annotation system to assist students in online reading, and the result shows that the effect of scaffolding on students' performance is 1.04 [25]. Abdelaziz and Zehmi designed a cognitive scaffolding to provide students with audiovisuals and picture materials, help students interact and provide timely feedback, etc., so as to help underachieving learners in middle schools to solve problems in English grammar learning. They found that the effect size of scaffolding on learners was 0.53 [26]. There is a large difference in effect size between the two studies. Therefore, we hypothesize that scaffolding in online learning might have different results for different grade levels.

The effectiveness of scaffoldings on different online learning outcome types is unclear. Scholars have reported the effects of scaffolding on knowledge learning in the cognitive domain, the affective domain, and the metacognitive domain. Yu and Pan explored the effects of problem generation scaffolding on students' academic achievement (cognitive domain), problem generation performance (cognitive domain), learning satisfaction (affective domain), and learning anxiety (affective domain) in online learning. They found that scaffolding is useful for learning knowledge in the cognitive domain, but it was ineffective in learning knowledge in the affective domain [8]. Avcı revealed that scaffolding is beneficial to developing students' meta-cognitive skills [27], while Bannert and Mengelkamp drew the opposite conclusion [24]. Does scaffolding have different effects on knowledge learning in the three domains? If so, we can take the learning outcome types as a moderator variable to understand how scaffolding affects different learning outcome types.

Learning modes (individual online learning vs. collaborative online learning) may be important factors affecting the effect of scaffolding in the online learning environment. For example, Tegos and Demetriadis provided a conversational agent to assist students' online collaborative learning, and results show that it can significantly improve students' online learning performance [28]. Some studies reached a similar conclusion [18,29]. Casselman, Eichler, and Atit provided scaffolding for personal study and found that scaffolding had little effect on improving students' learning performance [30]. Yu and Pan also reported similar conclusions [8], but other researchers have come to the opposite conclusion [17,26]. Therefore, it is necessary to explore whether scaffolding plays the same role in different online learning modes.

The effect of different scaffolding types in online learning is unclear. Kao, Chiang, and Sun customized a digital game and designed demonstration scaffolding (strategic scaffolding), and they marked critical feature scaffolding (conceptual scaffolding) to evaluate its effects on learning [31]. They found that conceptual scaffolding is better than strategic scaffolding in improving students' conceptual knowledge learning. A message tag (procedural scaffolding) and sentence opener (meta-cognitive scaffolding) were designed by AK to assist students in sending messages in online collaborative learning, and the influence of these two scaffoldings on students' learning results was explored. It was found that both scaffoldings had no influence on students' learning results [32]. These findings indicate controversies regarding the effect of different scaffolding types on learning outcomes. Therefore, it is necessary for us to explore whether scaffolding types will affect the results of online learning.

In this meta-analysis, we discussed whether learning disciplines, educational levels, outcome types, learning modes, and scaffolding types will influence the effect of scaffolding on students' online performance. The results can assist in finding the factors that affect the effect of online scaffolding.

3. Method

3.1. Research Method

In this meta-analysis, the time range of searching relevant papers was set between 2011 and 2021. In order to ensure a comprehensive collection of the relevant literature, we conducted electronic and manual searches of journal articles, and we used keywords to search the following electronic databases: Web of Science, ProQuest, ERIC, EBSCO, ScienceDirect, Springer, and Google Scholar. In addition, we manually searched the following top-tier journals in the education field, including Computers & Education, the Journal of Computer Assisted Learning, the Journal of Educational Technology & Society, Educational Technology Research and Development, and the British Journal of Educational Technology to identify any related articles that might have been missed in the process of database search. Additionally, we used the following keywords: (a) "scaffolds", (b) "scaffolding", (c) "prompt", (d) "instructor support", (e) "online learning", and (f) "distance learning".

3.2. Research Process

3.2.1. Selection Criteria

The study used a checklist and a flow diagram from PRISMA guidelines to help us improve the quality of systematic reviews. The specific literature screening process is shown in Figure 1. To examine the effect of scaffolding for students' online learning performance, we applied the following criteria to select articles for our analysis: (1) the research topic is about the effect of scaffolding on students' online learning performance; (2) the studies were conducted between 2011 and 2021; (3) the studies were written in English; (4) the study design was either experimental or quasi-experiment; and (5) complete research data should be reported, such as sample size, mean, and SD, so as to facilitate the calculation of effect size. A total of 2379 articles were screened out in the initial search. After excluding the articles that do not meet the screening criteria, a total of 32 articles met the requirements.

3.2.2. Coding Scheme

The study was coded by two researchers after obtaining the eligible literature. The coding objects include experimental disciplines, grade levels, learning outcome types, learning modes, and scaffolding types. The specific coding schemes are as follows.

1. Experimental disciplines, including chemistry, language and literature, computer science, mathematics, educational technology, science, and others
2. Grade levels: the sub-categories include elementary, secondary, and college
3. Types of learning outcomes, including learning outcomes in the cognitive domain, affective domain, and meta-cognitive domain
4. Learning modes, including two kinds of scaffolding for individual or collaborative online learning
5. Scaffolding types, including conceptual scaffolding, meta-cognitive scaffolding, strategic scaffolding and procedural scaffolding

In the coding process, two researchers first coded 10% of the articles that met the standard. They found their coding differences through comparison, and then they resolved the coding differences through discussion, and then they continued coding the rest of the articles. If there was any controversy again, it was resolved through discussion, until a consistent coding scheme is formed.

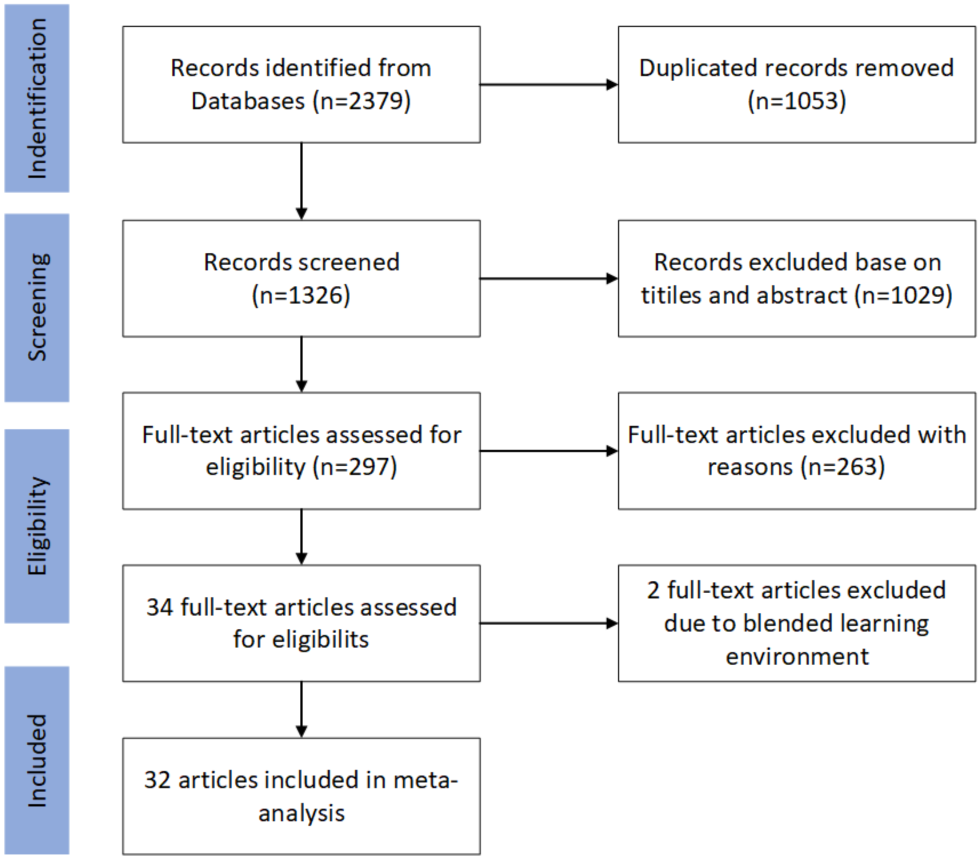

Figure 1. Search screening process.

3.2.3. Calculation of Effect Size

For data analysis, we utilized a random effects model to synthesize the effect sizes. According to Cohen's theory, d = 0.5 and d = 0.8 classify the effect sizes as small, medium, and large effects. Then, we used the Q statistics and I2 to evaluate the homogeneity of effect sizes. All analyses were conducted by Review Manager 5.3.

3.2.4. Publication Bias

To ensure the accuracy of the calculation results, we utilized a funnel plot to test publication bias. Result are shown in Figure 2, which shows a symmetrical distribution of effect sizes on both sides of the average effect size, which indicates that the publication bias of the included research is less likely, and the conclusion is more reliable [33].

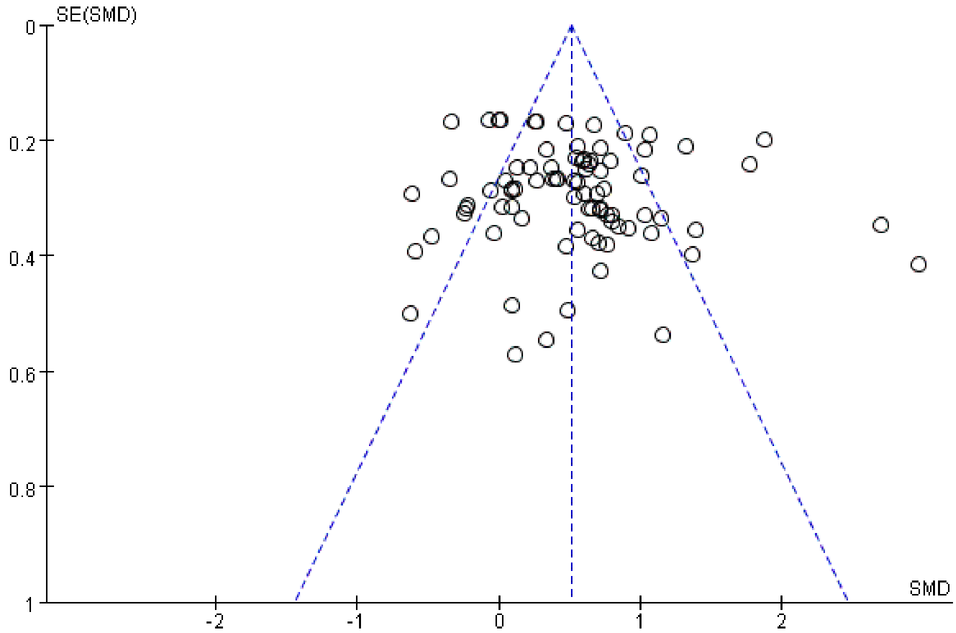

Figure 2. Funnel plot for the effect of scaffolding on students' online learning performance.

4. Results and Discussion

4.1. The Impact of Scaffolding on Students' Online Learning Performance

As summarized in Table 1, the overall effect of using scaffolding on online learning was 0.53 ($p < 0.001$), with a 95% confidence interval of 0.41–0.66, which suggests that scaffolding in online learning is significantly more effective than learning without scaffolding, and this included a medium effect size.

Table 1. Overall effect size of using scaffolding in online learning.

	k	d	z	95%CI	Q-Value	I2
ALL studies	83	0.53	8.42 ***	0.41–0.66	368.19	78%

CI confidence interval. *** $p < 0.001$.

This result is consistent with previous research findings [15,23,34]. It can be inferred that the mechanism scaffolding's impact on students' online learning performance is that scaffolding can improve the benefits of online learning by guiding learners in online learning, helping them overcome problems, such as disorientation and cognitive load in online learning or improving learning motivation [27,35]. With the assistance of scaffolding, students can fully utilize their autonomy in online learning so as to achieve their goals or engage in practices that are usually impossible. According to Zhang, Hsu, Wang, and Ho, scaffolding is beneficial for students to solving learning difficulties, promoting inquiry practice, and improving their inquiry ability, all of which contribute to enhancing their online learning performance [36]. Song and Kim's study also mentions that providing an interactive self-regulating scaffolding can improve learners' self-regulation level and initiative when they are learning online, thereby enhancing learners' online learning performance [20].

4.2. Effect Sizes of Moderator Variables

As listed in Table 1, the result of the Q statistic ($Q = 368.19$, $p < 0.001$,) shows that there is heterogeneity in effect sizes among the 83 included studies. The I2 statistic was computed to further analyze the heterogeneity across these findings. Typically, 25%, 50%, and 75% of I2 test results classify heterogeneity as low, medium, and high grade. The resulting I2 index of 78% in this research is regarded as high. This confirms the appropriateness of using the random effects model for data analysis, and it is necessary to find out potentially important moderator variables through subgroup analysis.

4.2.1. The Impact of Scaffolding on Students' Online Learning Performance in Different Learning Disciplines

It is necessary to discuss whether scaffolding is suitable for all disciplines and whether scaffolding has different effects in different subjects. The disciplines covered in this study include language and literature, chemistry, computer science, mathematics, science, and educational technology. The results show that the effect of scaffolding on online learning in these disciplines is greater than 0.2, with chemistry, mathematics, computer science, and educational technology showing effect sizes greater than 0.5 (as shown in Table 2). The order of the effect size among different disciplines is as follows: chemistry > mathematics > computer science > educational technology > science > language and literature. The results show that the effects of scaffolding in online learning are more pronounced in the mathematics domain compared to language learning, which means that scaffolding may be particularly useful in addressing well structured online problems. The difference in effect sizes among groups was $p = 0.54$, suggesting that there is no significant difference among different disciplines. This suggests that, although each discipline has its unique characteristics, scaffolding is suitable for online learning across all disciplines.

Table 2. Effect sizes of each learning discipline.

Learning Discipline	k	n	d	95%CI	z	*p*
chemistry	5	156	0.79	[0.46, 1.12]	4.72 ***	0.000
mathematics	6	635	0.66	[0.10, 1.22]	2.29 *	0.020
computer science	9	486	0.65	[0.44, 0.87]	5.99 ***	0.000
language and literature	14	709	0.38	[0.03, 0.74]	2.13 *	0.030
science	16	1032	0.45	[0.24, 0.67]	4.14 ***	0.000
educational technology	16	1074	0.61	[0.31, 0.91]	3.96 ***	0.000
other	17	1074	0.48	[0.16, 0.80]	2.90 ***	0.000

CI confidence interval. *** $p < 0.001$; * $p < 0.05$.

4.2.2. The Impact of Scaffolding on Students' Online Learning Performance in Different Grade Levels

We examined the effect of scaffolding in online learning across different grade levels. According to Table 3, a medium effect size was found for engaging scaffolding in online learning of elementary school students (d = 0.45, $p < 0.001$), secondary school students (d = 0.57, $p < 0.001$), and university students (d = 0.54, $p < 0.001$). According to the results of Q test (Q (2) = 0.29, $p = 0.86 > 0.05$), there is no statistical significance difference between the effect sizes of these learner populations.

Table 3. Effect sizes of grade level.

Grade Level	k	n	d	95%CI	z	*p*
elementary	12	696	0.45	[0.09, 0.80]	2.47 ***	0.000
secondary	21	1715	0.57	[0.26, 0.87]	3.66 ***	0.000
college	50	2755	0.54	[0.40, 0.67]	7.86 ***	0.000

CI confidence interval. *** $p < 0.001$.

Our study finds that scaffolding is suitable for all learner populations when conducting online learning. This result is similar with the findings of Belland, Walker, Kim, and Lefler [37], although their research focused on SETM education. This result suggests that instructional designers can set up scaffolding for online learning among students of different grade levels.

4.2.3. The Impact of Scaffolding on Students' Online Learning Performance in Different Learning Outcome Types

Scaffolding plays a crucial role in students' online learning. In order to explore whether there are differences in the effects of scaffolding on different learning outcome types, we conducted further analysis. According to the results, presented in Table 4, the effect of scaffolding on the affective domain is 0.67 ($p < 0.001$), on the cognitive domain it is 0.48 ($p < 0.001$), and on the meta-cognitive domain it is 0.63 ($p < 0.001$), indicating that scaffolding has a moderate impact on various learning outcomes.

Table 4. Effect sizes of learning outcome type.

Learning Outcome Type	k	n	d	95%CI	z	*p*
cognitive	59	3337	0.48	[0.35, 0.61]	7.26 ***	0.000
affective	15	1418	0.67	[0.29, 1.06]	3.46 ***	0.000
meta-cognitive	9	411	0.63	[0.33, 0.92]	4.13 ***	0.000

CI confidence interval. *** $p < 0.001$.

Our findings indicate the effect of scaffolding on affective domain is significantly stronger compared to the other domains. One possible explanation for this difference is that, when compared with the affective domain, it is difficult to acquire knowledge and skills in the cognitive domain and meta-cognitive domain. For example, it takes a lot of time and energy to cultivate higher-order thinking ability in the meta-cognitive domain [38]. Therefore, it is relatively reasonable that scaffolding has a greater impact on the affective domain of online learning than on the cognitive domain and meta-cognitive domain under the shorter-term interventions.

4.2.4. The Impact of Scaffolding on Students' Online Learning Performance in Different Learning Modes

We compared the effect of scaffolding on personal online learning and collaborative online learning. Results are listed in Table 5. A medium effect size was reported for scaffolding in both personal online learning (d = 0.49, $p < 0.001$) and collaborative online learning (d = 0.68, $p < 0.001$). According to the Q-test, there is no statistical significance in the effect of scaffolding on the two online learning modes (Q (1) = 2.88, $p = 0.09 > 0.05$).

Table 5. Effect sizes of learning mode.

Learning Type	k	n	d	95%CI	z	*p*
Online individual learning	62	3790	0.49	[0.33, 0.64]	6.21 ***	0.000
Online collaborative learning	21	1376	0.68	[0.52, 0.85]	7.91 ***	0.000

CI confidence interval. *** $p < 0.001$.

This shows that scaffolding is not only beneficial for individual online learning, but it also has a more substantial impact on collaborative online learning. One possible explanation for this is that scaffolding can assist teams to set goals, to monitor and to control the collaboration process, and to evaluate and to reflect after the collaborative activities finished, thereby improving the efficiency and effectiveness of online collaboration. For example, some researchers have explored the impact of scaffolding on students' collaborative online learning and have found that scaffolding has a significant impact on students' behavior and learning performance [14,34]. Therefore, when conducting instructional design for online learning, instructional designers should not only consider setting up scaffolding for individual learning, but also for collaborative learning activities to support students' online learning.

4.2.5. The Impact of Different Scaffolding Types on the Students' Online Learning Performance

To examine the effect of different scaffolding types on students' online learning performance, we analyzed the effects of different scaffolding types (meta-cognitive, procedural, conceptual, and strategic) on online learning results. The results are listed in Table 6. Conceptual scaffolding (d = 0.85, $p < 0.001$), meta-cognitive scaffolding (d = 0.49, $p < 0.001$), and procedural scaffolding (d = 0.47, $p < 0.001$) have greater impact on students' online learning outcome than strategic scaffolding (d = 0.26, $p > 0.05$). The results of the Q-test (Q (3) = 9.41, $p = 0.02 < 0.05$) showed that the differences in effect quantity among scaffolding types were statistically significant.

Table 6. Effect sizes of scaffolding type.

Scaffolding Type	k	n	d	95%CI	z	p
meta-cognitive	37	2062	0.49	[0.30, 0.69]	5.07 ***	0.000
conceptual	17	1056	0.85	[0.59, 1.11]	6.34 ***	0.000
procedural	19	1514	0.47	[0.21, 0.72]	3.60 ***	0.000
strategic	10	543	0.26	[−0.03, 0.55]	1.77	0.080

CI confidence interval. *** $p < 0.001$.

The possible reason for the smaller effect size of strategic scaffolding compared to other scaffolding types could be that there are few articles that focused on the application of strategic scaffolding included in this study. Therefore, it is necessary to expand the search scope and increase the proportion of articles on the application of strategic scaffolding in subsequent studies. In addition, large effect sizes were reported for conceptual scaffolding, while meta-cognitive scaffolding and procedural scaffolding have medium effects. Meaningful learning involves establishing connection between previous and new knowledge. In order to realize meaningful learning, learners need to understand new knowledge, try to establish a connection with the prior knowledge, and then test their learning level through tests and other means to find out their own shortcomings. Then, they need to make adjustments, and, finally, they need to realize meaningful learning. In this process, teachers need to provide learners with guidance on procedures, methods, and strategies so that learners can learn efficiently. We found that students' online learning performance is closely related to students' understanding of new knowledge, so conceptual scaffolding in the learning process is very important, as it can help learners to identify learning content, guide their thinking, and clarify the logical connections among knowledge, thereby deepening their understanding of new knowledge. However, it does not deny the importance of the other three scaffolding types in students' online learning process, but, from the results, conceptual scaffolding has the greatest impact on learners' online learning.

Scaffolding is very important for students to learn online, but the effect of scaffolding is restricted by many factors. Our research results are credible because the conclusion is based on a comprehensive statistical analysis. However, the conclusion drawn through meta-analysis is based on inference, rather than factor analysis result, which is easily influenced by some adjustment variables. Therefore, caution is needed in promoting results.

5. Summary and Implications

This study conducted a meta-analysis of 32 studies on the effect of scaffolding in online learning over the past 10 years and analyzed the effect of scaffolding under the adjustment of learning disciplines, grade levels, learning outcome types, learning modes, and scaffolding types in online learning. Our findings revealed the following:

- Scaffolding has positive impact on students' online learning performance.
- Scaffolding is more effective in some subjects' online learning, such as chemistry, mathematics, and computer and educational technology.
- Scaffolding has a positive impact on students at different grade levels.

- Scaffolding has a higher impact on the affective domain than on the cognitive domain and the meta-cognitive domain.
- Compared to personal online learning, scaffolding is more conducive to collaborative online learning.
- Compared to strategy scaffolding, procedural scaffolding, conceptual scaffolding, and meta-cognitive scaffolding are more conducive to students' online learning.

5.1. Implications for Practice

This study explores the effect of scaffolding on students' online learning and the factors that influence its effectiveness. In order to help instructional designers in designing effective scaffolding to assist students' online learning, this study presents some suggestions, based on our research results.

Firstly, scaffolding can be set up for online learning across all grade levels and disciplines. Scaffolding has a positive impact on learners' online learning performance, and there are not significant differences in different educational levels. Therefore, instructional designers should consider incorporating scaffolding into online learning courses to support learners' learning. At the same time, it should be noted that knowledge acquisition in the cognitive and metacognition domains requires learners to spend more time and energy, and instructional designers need to provide long-term scaffolding support.

Secondly, instructional designers can set different scaffolding types according to the type of online learning activities. These activities may involve knowledge learning, discussions, tests, etc. Instructional designers need to set up suitable scaffolding to support learners' learning according to the characteristics of different activities. For example, when learners are learning new concepts, teachers need to provide conceptual scaffolding in time to help learners think about the meaning and characteristics of concepts.

Thirdly, instructional designers can use AI technology to set up intelligent scaffolding. This type of scaffolding is different from traditional scaffolding, as it is dynamic and responsive. It can find the shortcomings of learners based on the analysis of learners' online learning data, and then it can provide personalized scaffolding support to help learners actively solve the difficulties encountered, thereby improving learning efficiency.

Lastly, instructional designers need to analyze potential difficulties encountered in the online learning environment in advance and provide targeted scaffolding support for learners. For example, according to the obstacle learners may encounter in meaningful learning, scaffolding support, such as expert guidance and automatically handled non-salient routine tasks, can be set up to reduce learners' cognitive load and to improve learning outcomes [11].

Overall, by implementing these suggestions, instructional designers can optimize the use of scaffolding in online learning and enhance the learning experience and outcomes for students.

5.2. Implications for Future Studies

It is necessary to point out some limitations of the current literature for future research. First, this review contains a few articles about scaffolding's affective and meta-cognitive results in online learning. Future research can consider expanding the proportion of research on non-cognitive results within the review.

Second, all the articles included in this study are published in English, and the research results may deviate from the actual situation. Therefore, in future research, we can incorporate research articles on the scaffolding effect that are published in other languages.

Third, meta-analysis can only synthesize the results of quantitative research design, so it can not contain the results of other research designs. Future researchers can further explore the effect of scaffolding in online learning through design-based research and case studies to provide additional insights and perspectives.

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References

1. Toader, T.; Safta, M.; Titirișcă, C.; Firtescu, B. Effects of Digitalisation on Higher Education in a Sustainable Development Framework—Online Learning Challenges during the COVID-19 Pandemic. *Sustainability* **2021**, *13*, 6444. [CrossRef]
2. Adarkwah, M.A. "I'm not against online teaching, but what about us?": ICT in Ghana post COVID-19. *Educ. Inf. Technol.* **2021**, *26*, 1665–1685. [CrossRef]
3. Tang, T.; Abuhmaid, A.M.; Olaimat, M.; Oudat, D.M.; Aldhaeebi, M.; Bamanger, E. Efficiency of flipped classroom with online-based teaching under COVID-19. *Interact. Learn. Environ.* **2023**, *31*, 1077–1088. [CrossRef]
4. Hwang, G.-J.; Hung, C.-M.; Chen, N.-S. Improving learning achievements, motivations and problem-solving skills through a peer assessment-based game development approach. *Educ. Technol. Res. Dev.* **2014**, *62*, 129–145. [CrossRef]
5. Valencia-Vallejo, N.; López-Vargas, O.; Sanabria-Rodríguez, L. Effect of Motivational Scaffolding on E-Learning Environments: Self-Efficacy, Learning Achievement, and Cognitive Style. *J. Educ. Online* **2018**, *15*. [CrossRef]
6. Wang, T. Implementation of Web-based argumentation in facilitating elementary school students to learn environmental issues. *J. Comput. Assist. Learn.* **2014**, *30*, 479–496. [CrossRef]
7. Valle, N.; Antonenko, P.; Valle, D.; Dawson, K.; Huggins-Manley, A.C.; Baiser, B. The influence of task-value scaffolding in a predictive learning analytics dashboard on learners' statistics anxiety, motivation, and performance. *Comput. Educ.* **2021**, *173*, 104288. [CrossRef]
8. Yu, F.Y.; Pan, K.J. The Effects of Student Question-Generation with Online Prompts on Learning. *J. Educ. Technol. Soc.* **2014**, *17*, 267–279.
9. van de Pol, J.; Volman, M.; Beishuizen, J. Scaffolding in Teacher–Student Interaction: A Decade of Research. *Educ. Psychol. Rev.* **2010**, *22*, 271–296. [CrossRef]
10. Wesiak, G.; Steiner, C.M.; Moore, A.; Dagger, D.; Power, G.; Berthold, M.; Albert, D.; Conlan, O. Iterative augmentation of a medical training simulator: Effects of affective metacognitive scaffolding. *Comput. Educ.* **2014**, *76*, 13–29. [CrossRef]
11. Quintana, C.; Reiser, B.; Davis, E.A.; Krajcik, J.; Fretz, E.; Duncan, R.G.; Kyza, E.; Edelson, D.C.; Soloway, E. A Scaffolding Design Framework for Software to Support Science Inquiry. *J. Learn. Sci.* **2004**, *13*, 337–386. [CrossRef]
12. Dennen, V.P.; Burner, K.J. The cognitive apprenticeship model in educational practice. In *Handbook of Research on Educational Communications and Technology*; Routledge: Abingdon, UK, 2008; pp. 425–439.
13. Rienties, B.; Giesbers, B.; Tempelaar, D.; Lygo-Baker, S.; Segers, M.; Gijselaers, W. The role of scaffolding and motivation in CSCL. *Comput. Educ.* **2012**, *59*, 893–906. [CrossRef]
14. Zheng, L.; Li, X.; Zhang, X.; Sun, W. The effects of group metacognitive scaffolding on group metacognitive behaviors, group performance, and cognitive load in computer-supported collaborative learning. *Internet High. Educ.* **2019**, *42*, 13–24. [CrossRef]
15. Lin, Y.-R.; Fan, B.; Xie, K. The influence of a web-based learning environment on low achievers' science argumentation. *Comput. Educ.* **2020**, *151*, 103860. [CrossRef]
16. Choo, S.S.Y.; Rotgans, J.I.; Yew, E.H.J.; Schmidt, H.G. Effect of worksheet scaffolds on student learning in problem-based learning. *Adv. Health Sci. Educ.* **2011**, *16*, 517–528. [CrossRef]
17. Yilmaz, R.; Yilmaz, F.G.K. Examination of the effectiveness of the task and group awareness support system used for computer-supported collaborative learning. *Educ. Technol. Res. Dev.* **2020**, *68*, 1355–1380. [CrossRef]
18. Jin, S.H. Using Visualization to Motivate Student Participation in Collaborative Online Learning Environments. *J. Educ. Technol. Soc.* **2017**, *20*, 51–62.
19. Valencia-Vallejo, N.; López-Vargas, O.; Sanabria-Rodríguez, L. Effect of a metacognitive scaffolding on self-efficacy, metacognition, and achievement in e-learning environments. *Knowl. Manag. E-Learn. Int. J.* **2019**, *11*, 1–19. [CrossRef]
20. Song, D.; Kim, D. Effects of self-regulation scaffolding on online participation and learning outcomes. *J. Res. Technol. Educ.* **2021**, *53*, 249–263. [CrossRef]
21. Doo, M.Y.; Bonk, C.; Heo, H. A Meta-Analysis of Scaffolding Effects in Online Learning in Higher Education. *Int. Rev. Res. Open Distrib. Learn.* **2020**, *21*, 60–80. [CrossRef]

22. Jumaat, N.F.; Tasir, Z. Instructional Scaffolding in Online Learning Environment: A Meta-analysis. In Proceedings of the 2014 International Conference on Teaching and Learning in Computing and Engineering, Kuching, Malaysia, 11–13 April 2014; pp. 74–77.
23. Lin, P.-C.; Hou, H.-T.; Chang, K.-E. The development of a collaborative problem solving environment that integrates a scaffolding mind tool and simulation-based learning: An analysis of learners' performance and their cognitive process in discussion. *Interact. Learn. Environ.* **2022**, *30*, 1273–1290. [CrossRef]
24. Bannert, M.; Mengelkamp, C. Scaffolding Hypermedia Learning through Metacognitive Prompts. In *International Handbook of Metacognition and Learning Technologies (Springer International Handbooks of Education)*; Springer: Berlin/Heidelberg, Germany, 2013; pp. 171–186.
25. Chen, C.-M.; Li, M.-C.; Chen, T.-C. A web-based collaborative reading annotation system with gamification mechanisms to improve reading performance. *Comput. Educ.* **2020**, *144*, 103697. [CrossRef]
26. Abdelaziz, H.A.; Al Zehmi, O. E-cognitive scaffolding: Does it have an impact on the English grammar competencies of middle school underachieving students? *Open Learn. J. Open Distance E-Learn.* **2021**, *36*, 5–28. [CrossRef]
27. Avcı, U. Examining the role of sentence openers, role assignment scaffolds and self-determination in collaborative knowledge building. *Educ. Technol. Res. Dev.* **2020**, *68*, 109–135. [CrossRef]
28. Tegos, S.; Demetriadis, S. Conversational Agents Improve Peer Learning through Building on Prior Knowledge. *J. Educ. Technol. Soc.* **2017**, *20*, 99–111.
29. Özçinar, H. Scaffolding computer-mediated discussion to enhance moral reasoning and argumentation quality in pre-service teachers. *J. Moral Educ.* **2015**, *44*, 232–251. [CrossRef]
30. Casselman, M.D.; Eichler, J.F.; Atit, K. Advancing multimedia learning for science: Comparing the effect of virtual versus physical models on student learning about stereochemistry. *Sci. Educ.* **2021**, *105*, 1285–1314. [CrossRef]
31. Kao, G.Y.-M.; Chiang, C.-H.; Sun, C.-T. Customizing scaffolds for game-based learning in physics: Impacts on knowledge acquisition and game design creativity. *Comput. Educ.* **2017**, *113*, 294–312. [CrossRef]
32. Ak, S. The role of technology-based scaffolding in problem-based online asynchronous discussion. *Br. J. Educ. Technol.* **2016**, *47*, 680–693. [CrossRef]
33. Shi, H.; Cheung, A.C.; Cheung, E.S. The Impact of Stratified Teaching on the Academic Performance of Chinese Middle School Students: A Meta-Analysis. *Sci. Insights Educ. Front.* **2020**, *7*, 735–760. [CrossRef]
34. Gijlers, H.; Weinberger, A.; van Dijk, A.M.; Bollen, L.; van Joolingen, W. Collaborative drawing on a shared digital canvas in elementary science education: The effects of script and task awareness support. *Int. J. Comput. Collab. Learn.* **2013**, *8*, 427–453. [CrossRef]
35. Kim, J.Y.; Lim, K.Y. Promoting learning in online, ill-structured problem solving: The effects of scaffolding type and metacognition level. *Comput. Educ.* **2019**, *138*, 116–129. [CrossRef]
36. Zhang, W.-X.; Hsu, Y.-S.; Wang, C.-Y.; Ho, Y.-T. Exploring the Impacts of Cognitive and Metacognitive Prompting on Students' Scientific Inquiry Practices Within an E-Learning Environment. *Int. J. Sci. Educ.* **2015**, *37*, 529–553. [CrossRef]
37. Belland, B.R.; Walker, A.E.; Kim, N.J.; Lefler, M. Synthesizing Results from Empirical Research on Computer-Based Scaffolding in STEM Education: A Meta-Analysis. *Rev. Educ. Res.* **2016**, *87*, 309–344. [CrossRef]
38. Halpern, D.E. Teaching critical thinking for transfer across domains Disposition, skills, structure training, and metacognitive monitoring. *Am. Psychol.* **1998**, *53*, 449. [CrossRef] [PubMed]