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Effects of Scaffolding Types and Individual Metacognition Levels on Learning Achievement in Online Collaborative Argumentation

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This study examined the effects of scaffolding types (Toulmin's Argument Pattern: TAP or Argumentation Vee Diagram: AVD) and individual metacognition levels (low or high) on students' learning achievement in online collaborative argumentation. A total of 191 Chinese undergraduates took part in this study. They were randomly assigned to either the TAP scaffolding, AVD scaffolding, or no scaffolding condition. They were teamed up in small groups of two or three students to argue with their peers using SNS as the online collaborative argumentation environment. The results revealed that students in the TAP and AVD scaffolding conditions did not gain significantly higher retention or transfer scores than students without scaffolding. However, students in the TAP scaffolding condition significantly outperformed those in the AVD scaffolding condition on transfer scores. Individual metacognition did not significantly affect learning achievement in online collaborative argumentation. Additionally, there was no significant interaction effect between scaffolding types and individual metacognition levels on retention or on transfer. The findings have implications for scaffolding design for online collaborative argumentation and also suggest that more attention should be paid to social metacognition rather than to individual metacognition when students work collaboratively.

Keywords : Scaffolding, Individual metacognition, Learning achievement, Online collaborative argumentation

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Introduction

According to Vygotsky (1978), social interaction plays a significant role in the learning process. Argumentation, as one of the effective strategies to initiate deep social interaction among learners, not only motivates them but also engages them in learning (Chinn, 2006). In recent years, argumentation has been studied in a variety of contexts including science, history, language arts, multidisciplinary, and interdisciplinary contexts (Garrecht, Reiss, & Harms, 2021; Guilfoyle, Hillier, & Fancourt, 2021; Litman & Greenleaf, 2018). Many studies have also indicated that collaborative argumentation, in which students collaborate to construct and critique arguments, can enhance conceptual understanding, knowledge co-elaboration, complex reasoning skills, and problem-solving abilities (Noroozi et al., 2012).

In order to support and engage learners in argumentative activities, Social Networking Services (SNSs) have been utilized because they allow users to engage in social relationships and share information (Greenhow, Gibbins, & Menzer, 2015). However, SNS-based online collaborative argumentation has encountered some difficulties. On the one hand, structure, which may be necessary for learning, is the missing element in SNSs. As a result, the quality of argumentation tends to be low, and contradictory viewpoints and inconsistencies are often dismissed instead of being critically assessed (Tsovaltzi et al., 2015). On the other hand, argumentation itself is a complex and challenging cognitive process. High-quality argumentative discourse in instructional settings requires students' domain-specific and domain-general knowledge of argumentation (Baker et al., 2007). Although students gain a certain amount of domain-specific knowledge, they seldom learn how to argue based on this knowledge within their domain (Weinberger, Stegmann, & Fischer, 2005). Reasons for this include the fact that they may lack knowledge of the structure of argumentation and therefore are unable to create well-established interactive argumentation, which is necessary for collaborative learning (Kuhn & Udell, 2007). In addition, learners with limited cognitive or metacognitive abilities may have difficulty developing supporting arguments (Cho & Jonassen, 2002), because they may not use sufficient metacognitive skills during argumentation.

One of the most powerful teaching strategies is scaffolding, which can minimize the aforementioned difficulties. Scaffolding entails providing learners with contingent support to solve problems that are beyond their ability to solve on their own (Wood, Bruner, & Ross, 1976). Many studies (Belland et al., 2015; Jonassen & Kim, 2010; Kollar et al., 2014; Valero Haro et al., 2019) have demonstrated that scaffolding can assist learning in online collaborative argumentation, which in turn improves learners' knowledge acquisition as well as other skills. In this study, scaffolding was used as an intervention to give learners assistance of argumentation structure, because they were not familiar with online collaborative argumentation.

Earlier research focused on the impacts of scaffolding, but more recent efforts have been made to investigate the benefits of various scaffolding types (Kim, Vicentini, & Belland, 2021) and learner characteristics (Kollar et al., 2014; Yang et al., 2015). Learner characteristics refer to a learner's personal features, such as prior knowledge and cognitive style (Jonassen & Grabowski, 1993). Research has found that metacognition as an individual characteristic is associated with scaffolding, argumentation, and learning achievement (Gul & Shehzad, 2012; Jin & Kim, 2021; Kim & Lim, 2019). Metacognition is important in terms of the strategy (the capacity to comprehend the importance of employing a certain approach rather than just being capable of carrying it out) and awareness (the capacity to set aside one's own prior theory and consider alternatives) of argumentation (Garcia-Mila & Andersen, 2008). Therefore, it is essential to consider individual metacognition as an independent variable to explore its effect on learning achievement in online collaborative argumentation.

In sum, SNS-based online collaborative argumentation has not been sufficiently studied in empirical research. Moreover, research related to collaborative argumentation has shed light more on the argumentative knowledge construction than on the learning outcomes of the learning task itself. Additionally, there is no consensus on which type of scaffolding is most helpful in argumentation or on how individual metacognition levels might affect learning achievement. Consequently, it is essential to determine the relative benefits of various scaffolding types and the role of learners' individual metacognition in SNS-based collaborative argumentation. The aim of this study was to explore the influence of scaffolding types and individual metacognition levels on learning achievement in online collaborative argumentation. The main contribution of this study is the design of two different types of scaffolding to support SNS-based collaborative argumentation and to examine their effectiveness in terms of learning achievement. In this way, this study can provide suggestions for teachers to design SNS-based argumentative activities and offers several directions for further research on online collaborative argumentation. The research questions are as follows.

1. What are the effects of scaffolding types on students' retention and transfer scores in online collaborative argumentation?
2. What are the effects of individual metacognition levels on students' retention and transfer scores in online collaborative argumentation?
3. What are the effects of scaffolding types and individual metacognition levels on students' retention and transfer scores in online collaborative argumentation?

Theoretical Background and Hypotheses

Online collaborative argumentation

Argumentation has been referred to in various forms in the literature. For instance, Toulmin (1958) defined argumentation as the process of using evidence and reasons to convince others about the justification of a claim. The definition of argumentation given by Walton (2006) is a goal-oriented and interactive dialog in which participants prove or disprove presumptions in order to advance arguments.

Siegel (1995) argued that emphasizing argumentation as a pedagogical method is in line with educational objectives that seek to improve students' reasoning abilities, and that the purpose of argumentation is to resolve issues, problems, and disputes rationally.

In terms of the argument types, Aristotle distinguished among various forms of arguments, including didactic (apodictic), rhetorical, and dialectical (Andriessen, 2007; Van Eemeren, Grootendorst, & Henkemans, 1996). In the present study, the emphasis is on rhetorical and dialectical argument. Rhetorical argument is regarded as a dialog between an arguer and an audience, aiming at convincing the others to believe in the claim that the arguer believes in, regardless of what propositions the others hold (Jonassen & Kim, 2010; Noroozi et al., 2012). Dialectical argument, in contrast, refers to a dialog with the intention of resolving the disagreements between proponents of alternative claims (Jonassen & Kim, 2010; Noroozi et al., 2012). The former primarily focuses on constructing effective persuasive argumentation techniques, while the latter concentrates on finding resolutions by convincing opponents of one's superiority or seeking a compromise between different claims (Jonassen & Kim, 2010; Noroozi et al., 2012).

Collaborative argumentation has been employed in different educational settings. In collaborative argumentation, students can reflect on an issue or a problem by collaboratively constructing and critiquing arguments so as to come up with a (best) answer (Golanics & Nussbaum, 2008). A growing number of researchers have indicated that learners can benefit from computer-supported collaborative learning (CSCL) environments, which support learners in sharing, constructing, and representing arguments in multiple formats while arguing in teams (Noroozi et al., 2012; Vogel et al., 2016). In addition to special purpose collaborative argumentation software, some researchers have also shifted their attention from CSCL to SNSs (Greenhow et al., 2015; Puhl, Tsovaltzi, & Weinberger, 2015; Tsovaltzi et al., 2015, 2017). As SNS platforms encourage dialogic exchange and, simultaneously, incorporate social qualities regarded as vital for learning, they may be useful for collaborative learning (Laru, Näykki, & Järvelä, 2011) and argumentative knowledge construction (Tsovaltzi et al., 2015, 2017).

Although there have only been a few studies using SNSs to teach argumentation, the results have been encouraging. For example, Beach and Doerr-Stevens (2011) investigated how students used the Ning platform to argue about school policies regarding Internet use. The students challenged their own perspectives as well as each other's, recognized alternative arguments, and finally convinced school administrators to unblock websites that were previously blocked. SNSs, according to Beach and Doerr-Stevens, are more than just a platform for sharing information and can help students argue when the topics they discuss have a direct impact on their lives. Puhl et al. (2015) integrated Facebook discussion into seminars to explore how a group awareness tool with or without script support influenced learning outcomes as well as attitude change. The findings revealed that group awareness tools and scripts can augment Facebook in order to help learners acquire declarative knowledge more effectively. Furthermore, in a study analyzing the effects of argumentation scripts on Facebook, Tsovaltzi et al. (2017) found that students who used the argumentation scripts did not create higher quality arguments, but did make more argument elaboration and more knowledge co-construction. In accordance with the aforementioned studies, SNSs can provide students with support for developing their ability to defend arguments, generate counter-arguments, and expound on their own arguments.

Argumentation scaffolding

Wood et al. (1976) firstly referred to scaffolding as temporary, adaptive aids offered by a facilitator (adult or expert), which allows tutees (less expert) to solve a problem, fulfill a task or reach a goal that is beyond his unassisted capabilities. With the emergence of learning technology, the definition of scaffolding has broadened to include various tools, methods, and guidelines to assist learners (An, 2010; Feng

& Chen, 2014; Kim & Lim, 2019). Regarding the types of scaffolding, various types have been developed and applied in different domains. For example, Jafarigohar and Mortazavi (2017) employed the structuring and problematizing scaffolding to improve students' individual and social metacognition in English writing skills. Kim and Lim (2019) utilized the supportive and reflective scaffolding to enhance learning in online, ill-structured problem solving.

Prior studies have also examined the effects of argumentation scaffolding and different argumentation scaffolding types. For instance, Kollar et al. (2014) provided collaboration scripts and heuristic worked examples as scaffolds to support the social-discursive and individual components of mathematical argumentation skills among teacher students. The results demonstrated that both scaffolds had positive effects on the social-discursive component, and that students' prior achievement affected the influence of both scaffolds on both components of mathematical argumentation skills. Belland et al. (2015) applied computer-based scaffolds to assist middle school students in creating and evaluating evidence-based arguments about water quality. In their study, the computer-based scaffolding significantly affected the ability of students with lower academic achievement to evaluate arguments. Based on the abovementioned research findings, argumentation scaffolding tends to have a positive impact on learning outcomes. However, some researchers have also claimed that argumentation scaffolding does not always influence learning outcomes and result in positive effects on learning outcomes. For instance, Kern and Crippen (2017) found that two scaffolding strategies, namely self-explanation prompts for inscription and faded worked examples for argumentation, did not significantly influence the acquisition and retention of science content. In short, empirical results are inconsistent regarding the effects of argumentation scaffolding and its types in online collaborative argumentation.

In the current study, rhetorical argumentation scaffolding and dialectical argumentation scaffolding were applied to support online collaborative argumentation. Rhetorical argumentation scaffolding adopted Toulmin's argument pattern (TAP), which emphasized the elaboration of reasons to support one's own claim in a one-way manner with fewer rebuttals, with the intention of persuading others to accept one's own claim (Toulmin, 1958). The adopted TAP scaffolding consisted of four stages: claim, warrant, rebuttals, and modal qualifier. Dialectical argumentation scaffolding utilized Walton's VEE diagram (Nussaum, 2008, 2011), namely the Argumentation Vee Diagram (AVD), which aimed to generate as many rebuttals as possible, divided into pro and con claim statements, reason of elaboration by rebuttal, and integration. According to the findings on cognitive load of critical thinking strategies (Shehab & Nussbaum, 2015), AVD scaffolding, involving weighing refutations, actually entailed higher cognitive load than creating a design claim which is more sequential. On the other hand, with respect to learning achievement, this study focused on two dimensions: retention and transfer. However, there are inconsistent results regarding the effects of argumentation scaffolding on learning achievement in terms of retention and transfer. According to the characteristics of both scaffoldings, TAP scaffolding places more emphasis on the learners' own claim and does not generate as much cognitive load as AVD scaffolding, which might be more conducive to the internalization of knowledge. Thus, it can be expected that TAP scaffolding would result in learners' higher transfer scores. Regarding retention, collaborative learning will not lead to higher retention scores than individual learning (Kirschner, Paas, & Kirschner, 2009). Moreover, in Kern and Crippen's study (2017), one of the reasons why argumentative scaffolding did not significantly affect retention was the fact that argumentation scaffolding may have shifted the argumentation skill from extraneous to germane cognitive load instead of shifting the learning content to germane cognitive load. Hence, this study predicted that argumentation scaffolding and its types would have no significant effect on retention.

Metacognition

The term metacognition - also known as knowing about your own knowing or thinking about your own thinking - was coined in the 1970s by Flavell, who (1979) defined metacognition as the capacity to identify one's own thought processes, establish objectives, and assess one's own performance. Metacognition consists of two basic aspects: knowledge of cognition and regulation of cognition. Knowledge of cognition is the declarative aspects of knowledge. It refers to the awareness that individuals have of their own cognition or cognition in general. On the other hand, regulation of cognition is the procedural aspects of knowledge, which refers to various actions that help learners control their learning to accomplish a given task (Teng, 2017).

Individual metacognition has been demonstrated to affect academic achievement in science, reading, mathematics, and so on (Dori et al., 2018; Muhid et al., 2020; Young & Worrell, 2018). Additionally, empirical studies have shown that learners with high levels of individual metacognition have higher academic achievement. Although it has been noted that individual metacognition has a positive effect on academic achievement, there is still much exploration as to whether it affects achievement in collaborative learning. Some researchers (Goos, Galbraith, & Renshaw, 2002; Kim, 2011; Van De Bogart et al., 2017) have stated that individual metacognition is not as significant as social metacognition in collaborative learning. Furthermore, Iiskala et al. (2011) claimed that in collaborative learning, the metacognition required by members to solve problems is socially shared metacognition, which involves monitoring and regulation of joint cognitive processes. Similarly, Panadero and Järvelä (2015) advocated that group members can contribute to the group's problem-solving by mediating and sharing their metacognitive knowledge, and monitoring and controlling each other's actions.

Kim (2011) conjectured that individual metacognition imposes cognitive load on working memory, but this cognitive load is dispersed in collaborative learning conditions. Learners with low levels of individual metacognition can be assisted by their peers, so that there is no difference in academic achievement due to individual differences in metacognition. In his study, it was demonstrated that individual metacognition did not significantly influence learners' achievement in collaborative learning contexts. Furthermore, McNeese (2000) pointed out that learners in individual learning conditions focused more on the perceptual details of the problem situation, whereas learners in cooperative learning conditions focused more on metacognitive activities and collaboratively developed metacognitive strategies for ill-defined problem solving. In this way, individual differences in each member's metacognition may not significantly affect the outcome of collaborative learning if learners develop the necessary metacognitive strategies under collaborative learning conditions. Based on previous research, although online collaborative argumentation requires substantial metacognition, the metacognitive load will be dispersed and learners will collaborate to develop metacognitive strategies for learning. Therefore, it can be assumed that individual metacognition would not affect learning achievement in this present study.

Research hypotheses

Hypothesis 1. There will be no significant differences in retention and transfer depending on scaffolding types.

Hypothesis 1-1. The students with scaffolding will not significantly outperform those without scaffolding on retention.

Hypothesis 1-2. The students with TAP scaffolding will not significantly outperform those with AVD scaffolding on retention.

Hypothesis 1-3. The students with scaffolding will significantly outperform those without scaffolding on transfer.

Hypothesis 1-4. The students with TAP scaffolding will significantly outperform those with AVD scaffolding on transfer.

Hypothesis 2. There will be no significant differences in retention and transfer depending on individual metacognition levels.

Hypothesis 2-1. There will be no significant differences in retention depending on individual metacognition levels.

Hypothesis 2-2. There will be no significant differences in transfer depending on individual metacognition levels.

Hypothesis 3. There will be an interaction effect between scaffolding types and individual metacognition levels on retention and transfer.

Methods

Participants

A total of 193 undergraduate students from the College of Education of a university in China participated in this experiment. All students were randomly assigned to the comparison group, the TAP scaffolding group, or the AVD scaffolding group. In addition, students in each group were randomly assigned to small groups of two or three to argue with their peers. However, due to some absences during the experiment, two students were excluded, giving a final total of 191 participants in this study. The comparison group included 62 students (53 females and 9 males), while the TAP scaffolding group had 61 students (55 females and 6 males), and the AVD scaffolding group comprised 68 students (60 females and 8 males).

Learning environment, tasks and scaffolding

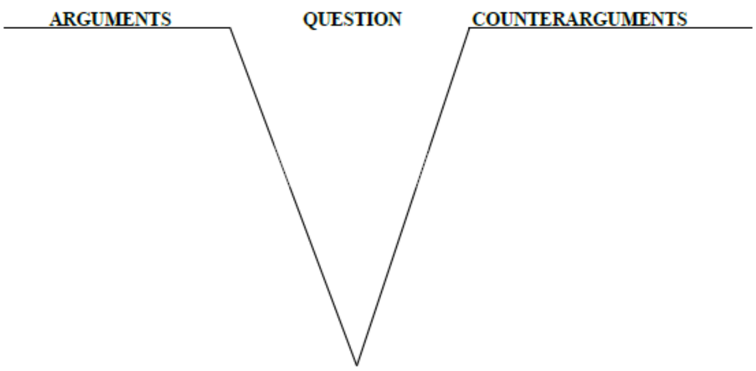
In this study, QQ, one of the popular SNSs in China, was provided as an online collaborative argumentation environment for students. Each student possessed an account and logged into QQ which was installed on a computer. Students were allowed to use text, pictures, and emotion icons to argue with each other synchronously. Moreover, students could check the chat records at any time if they missed some key points, and they could also upload learning materials for sharing information. Furthermore, each team was supported by the instructor and one research assistant in order to track students' learning process.

The learning tasks were designed for teacher students to learn about flipped learning, which is a popular pedagogical approach. There were three main learning stages. First, students were required to study the learning materials and individually answer five questions related to the flipped learning approach for preparing argumentation. The learning materials were provided in the forms of word files, PowerPoint and micro-video resources, involving definition of flipped learning pedagogy, production of micro-video resources, and conditions of current instructional reform in classes. Second, students in each team made use of the arguments to argue with their peers using different types of scaffolding. The topic of argumentation was whether the three course cases given by the instructor were flipped classrooms and whether flipped learning can improve learning outcomes. Lastly, each team was required to complete a report concerning results of argumentation.

Two different types of argumentation scaffolding were designed in this study. TAP scaffolding (Toulmin, 1958) was designed with the framework of rhetorical arguments, and AVD scaffolding (Nussbaum, 2008, 2011) was designed in light of Walton's dialogue theory and presumptive reasoning (Walton, 1996) within the framework of dialectical arguments (Jonassen & Kim, 2010). According to the TAP scaffolding (see Table 1), the rhetorical argumentation is composed of four stages: putting forward claims, articulating evidence, proposing rebuttals, and qualifier or presumable conclusions. AVD scaffolding (see Figure 1) was slightly revised to make it easier to fill out. The question was written in the Vee, while arguments and counterarguments were written outside the Vee. Additionally, a final conclusion and argument was written at the bottom of the Vee.

Table 1. TAP scaffolding

Stage 1: Putting forward claims	Each member of the collaborative group should firstly propose a claim regardless of its congruence.
Stage 2: Articulating evidence (backings or data) or warrants	Each member should provide the corresponding evidence supporting their own claim, which is differentiated as backings and data. Backings are referred to as grounding theories or historical events. Data usually encompass commonsense or a fact. Warrants are often implicit. Warrants aim to justify a claim by linking a fact to the claim.
Stage 3: Proposing rebuttals	Rebuttals intend to contradict the claim, not necessarily including the grounds supporting the counterargument.
Stage 4: Qualifier or presumable conclusion	The qualifier conveys the degree of force from data to claim. In this stage, presumable conclusions should be drawn from the above evidence, warrants, and rebuttals.



CRITICAL QUESTIONS

Look at all the above arguments, and answer each of the following questions?

	Circle Yes or No	Which Argument?
Are any of the arguments **not as important** as others?	Yes No	
Are any of the arguments **unlikely?**	Yes No	
Is there a **creative solution** to any problem raised?	Yes No	
Is the creative solution **practical**? (Consider costs.)	Yes No	
For any argument, can you think of any **examples to the contrary**? Or **other likely explanations?**	Yes No	

INTEGRATE

Using your answers, explain why one side is stronger (and the other side is weaker)? Or is there an "in-between" solution?

Figure 1. AVD scaffolding (Nussam, 2011)

Instruments

The researchers and two highly experienced instructors with authentic experience developed the pre- and post-tests, and checked if the tests' content, goals, wording, and the number of questions met the measurement requirements, thereby ensuring expert validity. The pre-test measured students' prior knowledge of instructional design based on the Dick-Carey Systems Approach Model. There were 20 multiple-choice items, with a perfect score of 20. The alpha value of the pre-test was .85.

The post-test evaluated students' learning achievement based on the instructional objectives regarding flipped learning. It included retention and transfer tests. The former consisted of 10 multiple-choice items with the maximal score of 20, whereas the latter included 10 subjective items with the maximal score of 80. The alpha value of the retention test was .86, while the inter-raters' reliability correlation coefficient of the transfer test was .84.

Individual metacognition level was measured using the State Metacognitive Inventory developed by O'Neil Jr and Abedi (1996). In all, 20 items were translated into Chinese, face-validated by three knowledgeable bilingual professors, and matched back with the original questionnaire to ensure that the translated version included all the nuances. The instrument items used a 5-point Likert scale. It comprised four factors, that is, awareness, cognitive strategy, planning, and self-checking. The alpha of each factor was .75, .63, .77, and .68, respectively. Additionally, the alpha value of this questionnaire was .91, which represents satisfactory internal consistency.

Experimental procedure

Before the experiment, students were divided into two different categories based on their median scores of individual metacognition (*Median* = 73): students with high levels of individual metacognition (N = 99) and students with low levels of individual metacognition (N = 92). They were then pre-tested to measure their prior knowledge of instructional design, and then each of them was randomly assigned to a collaborative learning team of triads or dyads. During the argumentative activities, one of the experimental groups took advantage of the AVD scaffolding; the other group utilized the TAP scaffolding, whereas students in the comparison group argued with each other without scaffolding. All the learning and argumentative activities took place in the computer room. After that, the students were post-tested to assess their learning achievement regarding retention and transfer. Concerning the treatment, the comparison group and the experimental groups received a 90-minute lesson once a week (1.5 hours/ week) over a period of 4 weeks, or a 180-mintue lesson once a week (3 hours/ week) for 2 weeks. Thus, this experiment lasted for 6 hours for each group.

Data analysis

This study consisted of two independent variables (scaffolding types and individual metacognition levels) and two dependent variables (retention and transfer) with the prior learning achievement as the covariate. The SPSS statistical software 22.0 package was utilized for data management and analysis. First, the data were analyzed through descriptive statistics. Second, in order to examine the effects of scaffolding types as well as individual metacognition levels on students' learning achievement, one-way multivariate analyses of covariance (MANCOVAs) and two-way MANCOVA were implemented. Furthermore, planned comparisons were also implemented to verify what type of scaffolding was more effective. All statistical tests were conducted at the .05 level of significance.

Results

The scores of the pretest (skewness = -.182, kurtosis = .521), retention (skewness = -.437, kurtosis = .081), and transfer (skewness = -.145, kurtosis = -.232) were normally distributed because the absolute values of skewness and kurtosis were less than 2 and 7, respectively (Curran, West, & Finch, 1996). Moreover, there were significant correlations between pretest and retention ($r = .196$, $p < .05$), between pretest and transfer ($r = .209$, $p < .05$), and between retention and transfer ($r = .385$, $p < .05$). Multicollinearity did not exist between the two dependent variables because the correlation coefficient r was not above .90 (Tabachnick & Fidell, 2012).

The effects of scaffolding types on retention and transfer

First, the assumptions for MANCOVA were tested. The equality of covariance between the groups was confirmed by Box's M test (*Box's M* = 12.896, $p = .019$). Tabachnick and Fidell (2012) suggested that multivariate group analysis can be conducted if Box's M test is not significant at the $p = .001$ level with unequal sample sizes. The homogeneity of regression slopes assumption was satisfied (*Wilks'* $\lambda = 0.954$, $F = 2.214$, $p > .05$). Afterwards, one-way MANCOVA was implemented for analyzing the effects of scaffolding types on learning achievement. Scaffolding types was the independent variable; retention and transfer were the dependent variables, while prior knowledge was the covariate. The results of descriptive data, one-way MANCOVA, and planned comparisons are shown in Table 2, Table 3, and Table 4, respectively.

Regarding retention, there was no statistically significant difference ($F = 1.242$, $p > .05$, $\eta^2 = 0.013$), supporting Hypothesis 1-1 and Hypothesis 1-2. In contrast, scaffolding types significantly influenced students' transfer scores ($F = 5.539$, $p < .05$, $\eta^2 = 0.056$). As illustrated in Table 4, the students with scaffolding did not get significantly higher transfer scores than those without scaffolding ($F = 2.434$, $p > .05$, $\eta^2 = 0.013$), rejecting Hypothesis 1-3. However, the students had significantly different transfer scores with the two different types of scaffolding ($F = 8.429$, p

< .05, η^2 = 0.043), supporting Hypothesis 1-4. Specifically, students with the TAP scaffolding (*Adjusted mean* = 42.07, *SE* = 1.33) significantly outperformed those with the AVD scaffolding (*Adjusted mean* = 36.66, *SE* = 1.29) on transfer scores.

Table 2. Descriptive data on learning achievement by scaffolding types

Scaffolding	N	Retention		Transfer	
		M(SD)	*Adj. M(SE)*	*M(SD)*	*Adj. M(SE)*
Comparison	62	13.05(2.32)	13.25(0.35)	35.89(10.58)	36.78(1.35)
TAP	61	13.87(3.21)	13.91(0.34)	41.90(12.11)	42.07(1.33)
AVD	68	13.48(2.53)	13.26(0.33)	37.63(8.93)	36.66(1.29)
Total	191	13.46(2.71)	-	38.43(10.80)	-

Note. Adj. M = Adjusted Mean

Table 3. Results of one-way MANCOVA for learning achievement by scaffolding types

Source	DV	*SS*	*df*	*MS*	*F*	*p*	η^2
Pretest	Retention	50.785	1	50.785	7.158	.008	.037
	Transfer	977.117	1	977.117	9.137	.003	.047
Scaffolding	Retention	17.618	2	8.809	1.242	.291	.013
	Transfer	1184.714	2	592.357	5.539*	.005	.056
Error	Retention	1326.737	187	7.095			
	Transfer	19998.312	187	106.943			

* $p < .05$
Note. DV = Dependent variable

Table 4. Planned comparisons for transfer by scaffolding types

Source	*SS*	*df*	*MS*	*F*	*p*	η^2
Comparison vs. TAP+AVD	260.264	1	260.264	2.434	.120	.013
TAP vs. AVD	901.446	1	901.446	8.429*	.004	.043
Error	19998.312	187	106.943			

* $p < .05$

The effects of individual metacognition levels on retention and transfer

To inspect the impact of individual metacognition levels on retention and transfer, one-way MANCOVA was conducted using individual metacognition levels as the independent variable, retention and transfer as the dependent variables, and prior knowledge as the covariate. There were no violations of assumptions. The covariance between groups was equal (*Box's M* = 3.017, $p > .05$) and the homogeneity of regression slopes assumption was also met (*Wilks'* $\lambda = 0.988$, $F = 1.160$, $p > .05$). Table 5 and Table 6 present the results of the descriptive data and one-way MANCOVA, respectively. As illustrated in Table 5, students with high levels of individual metacognition got higher retention and transfer scores than those with low levels of individual metacognition. However, as shown in Table 6,

Table 5. Descriptive data on learning achievement by individual metacognition levels

Metacognition	N	Retention		Transfer	
		M(SD)	*Adj. M(SE)*	*M(SD)*	*Adj. M(SE)*
Low	92	13.33(2.92)	13.28(0.28)	37.12(11.36)	36.93(1.10)
High	99	13.59(2.51)	13.63(0.27)	39.65(10.15)	39.82(1.06)
Total	191	13.46(2.71)	-	38.43(10.80)	-

Table 6. Results of one-way MANCOVA for learning achievement by individual metacognition levels

Source	DV	*SS*	*df*	*MS*	*F*	*p*	η^2
Pretest	Retention	56.301	1	56.301	7.907	.005	.040
	Transfer	1063.342	1	1063.342	9.617	.002	.049
Metacognition	Retention	5.757	1	5.757	0.809	.370	.004
	Transfer	396.056	1	396.056	3.582	.060	.019
Error	Retention	1338.598	188	7.120			
	Transfer	20786.969	188	110.569			

there was no significant difference in retention (F = 0.809, p > .05, η^2 = 0.004) or in transfer (F = 3.582, p > .05, η^2 = 0.019) scores according to the individual metacognition levels, which supported Hypothesis 2-1 and Hypothesis 2-2.

The effects of scaffolding types and individual metacognition levels on retention and transfer

In order to examine the interaction effect between scaffolding types and individual metacognition levels on retention and transfer, two-way MANCOVA was conducted, using scaffolding types and individual metacognition level as the independent variables, retention and transfer as the dependent variables, and prior knowledge as the covariate. The assumptions of homogeneity of covariances (*Box's M* = 31.416, p = .01) and regression slopes (*Wilks'* λ = 0.993, F = 0.310, p > .05) were both satisfied. Table 7 and Table 8 present the results of descriptive data and

Table 7. Descriptive data on learning achievement by scaffolding types and individual metacognition levels

Scaffolding	Metacog-nition	N	Retention		Transfer	
			M(SD)	*Adj. M(SE)*	*M(SD)*	*Adj. M(SE)*
Comparison	Low	26	12.90(2.59)	13.03(0.53)	35.19(9.50)	35.75(2.02)
	High	36	13.15(2.14)	13.42(0.46)	36.39(11.41)	37.55(1.75)
	Total	62	13.05(2.32)	13.22(0.35)	35.89(10.58)	36.65(1.35)
TAP	Low	29	13.85(3.70)	13.87(0.50)	41.62(13.71)	41.72(1.91)
	High	32	13.89(2.75)	13.94(0.47)	42.16(10.58)	42.39(1.82)
	Total	61	13.87(3.21)	13.91(0.34)	41.90(10.68)	42.06(1.32)
AVD	Low	37	13.22(2.43)	13.00(0.45)	34.95(9.68)	34.00(1.72)
	High	31	13.79(2.65)	13.56(0.49)	40.84(6.79)	39.82(1.87)
	Total	68	13.48(2.53)	13.28(0.34)	37.63(8.93)	36.91(1.29)
Total	Low	92	13.33(2.92)	13.30(0.28)	37.12(11.36)	37.16(1.08)
	High	99	13.59(2.51)	13.64(0.27)	39.65(10.15)	39.92(1.03)
	Total	191	13.46(2.71)	-	38.43(10.80)	-

Table 8. Results of two-way MANCOVA for learning achievement by scaffolding types and individual metacognition levels

Source	DV	*SS*	*df*	*MS*	*F*	*p*	η^2
Pretest	Retention	51.860	1	51.860	7.234	.008	.038
	Transfer	993.185	1	993.185	9.434	.002	.049
Scaffolding types(ST)	Retention	17.644	2	8.822	1.231	.295	.013
	Transfer	1144.814	2	572.407	5.437*	.005	.056
Individual metacognition levels(IML)	Retention	5.444	1	5.444	0.759	.385	.004
	Transfer	358.794	1	358.794	3.408	.066	.018
ST x IML	Retention	1.895	2	.947	0.132	.876	.001
	Transfer	237.848	2	118.924	1.130	.325	.012
Error	Retention	1319.136	184	7.169			
	Transfer	19370.541	184	105.275			
Total	Retention	36019.250	191				
	Transfer	304226.000	191				

$*p < .05$

two-way MANCOVA, respectively. As shown in Table 8, there was no significant interaction effect between scaffolding types and individual metacognition levels on retention (F = 0.132, p > .05, η^2 = 0.001) or on transfer (F = 1.130, p > .05, η^2 = 0.012), thus rejecting Hypothesis 3.

Discussion and Conclusion

The effects of scaffolding types and individual metacognition levels were investigated in this study on learning achievement in SNS-based online collaborative argumentation. First, although students in the TAP scaffolding condition gained slightly higher retention scores than those in the AVD scaffolding condition, and students in the AVD scaffolding condition obtained slightly higher retention scores than those in the comparison group, the analysis revealed that providing scaffolding and scaffolding types did not significantly influence students' retention scores. The findings seem to be related to the cognitive load when students engaged in collaborative argumentation. Kirschner et al. (2009) claimed that in the case of a simple recall task, individual retention efficiency in group learning is inferior to that in individual learning because working together elicits extraneous cognitive load.

Second, providing scaffolding had no significant effect on learners' transfer scores. In one previous study (Cho & Jonassen, 2002), scaffolding influenced the quality of argumentation during individual problem solving but not individual problem-solving performance. One interpretation of this finding was that the scaffolding influenced the transfer of argumentation abilities from group to individual performances, but problem-solving performance was less likely to emerge in individual performances since it was not explicitly scaffolded. With regard to scaffolding types, TAP scaffolding was more effective than AVD scaffolding in terms of enhancing learners' transfer scores. This result was in line with Shehab and Nussbaum's (2015) findings that AVD scaffolding involving weighing refutations actually entailed higher cognitive load than claims constructed sequentially. In other words, TAP scaffolding with the intention of persuading others to accept one's claim brought less cognitive load than AVD scaffolding with the aim of elaborating evidence for one's claim as well as rebutting others' reasons.

Third, individual metacognition did not significantly influence learners' retention or transfer scores in online collaborative argumentation, which corroborates findings from previous studies that students' individual metacognition had no significant difference for their achievement in collaborative learning conditions (Kim, 2011). Additionally, this result is consistent with the claim of many researchers (Goos et al., 2002; Iiskala et al., 2011) that individual metacognition does not play a crucial role in collaborative learning. However, it should be noted that this result did not provide direct empirical evidence for whether social metacognition affects learning outcomes in collaborative learning conditions.

Lastly, no interaction effect between scaffolding types and individual metacognition levels produced significant differences on retention or on transfer in online collaborative argumentation. It revealed that according to the individual metacognition levels, the effects of scaffolding types did not change, which meant that TAP scaffolding tends to be more helpful than AVD scaffolding on transfer. In addition, the effects of individual metacognition levels did not change due to different scaffolding types, which showed that individual metacognition levels did not significantly influence retention or transfer.

The limitations of this study and directions for a further study are as follows. To begin, students were randomly assigned into small teams in which two or three students argued together in the experiment, but this study did not consider the effect of team size. Further research can explore whether team size in an online collaborative argumentation will significantly influence learning achievement, and how many students in a team will lead to the most effective learning outcomes. Second, this study did not analyze students' social metacognition which hinders the deep understanding of the importance of social metacognition in collaborative learning. As a result, further research should investigate the role of social metacognition in online collaborative argumentation and also the interaction effect between scaffolding types and social metacognition levels. Lastly, the participants in this study were teacher students with the same knowledge background. Further research should seek to replicate this experiment involving students with different knowledge backgrounds.

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