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Collaboration Scripts for Argumentation Based on Activity Theory

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The purpose of this study is to develop collaboration scripts as an instructional means to facilitate argumentation in computer-supported collaborative learning, and to analyze their effects. To develop collaboration scripts for argumentation, researchers used activity theory as a conceptual framework and refined the design principles by design-based research. Using LAMS, collaboration scripts for argumentation were developed based on the ArgueGraph. To examine their effects, 72 participants were divided into two groups by internal scripts and randomly allocated to one of three external scripts. Applying mixed methods, researchers analyzed argumentation competence related to the cognitive aspect, examined self-efficacy related to the motivational aspect, and identified the factors influencing collaborative learning processes and outcomes. Researchers found that the internal script is a critical factor to determine the dimensions, degrees, and duration of improvement in argumentation competence. That is, learners with higher internal scripts improved highly in the quality of single arguments, while learners with lower internal scripts improved continuously in the quality of argumentation sequences. The effects of the external scripts varied with the internal script levels and supporting periods. Besides, collaboration scripts for argumentation had positive effects on learners' self-efficacy, and learners with higher internal scripts had better self-efficacy. The factors influencing collaborative learning processes and outcomes showed different results depending on the learning context. Therefore, when scripting learner's interaction in CSCL, researchers should design the scripts adaptable to a natural context of activities.

Keywords : Argumentation, Collaboration script, Activity theory, Design-based research, Internal script, External script, Computer-supported collaborative learning

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Introduction

Argumentation is an essential activity in constructing collaborative knowledge (Stegmann et al. 2007). However, learners may have difficulty in understanding the global processes of argumentation, and rarely perform argumentation spontaneously (King, 2007). One approach to facilitate argumentation involves the use of collaboration scripts in computer-supported collaborative learning (CSCL). Collaboration scripts can be defined as an instructional means that specify and sequence individual and collaborative learning activities (Kollar et al. 2006; Haake & Pfister, 2010; Stegmann et al. 2007). The rationale of collaboration scripts is to structure collaborative learning processes to trigger group interactions that may be infrequent in free collaboration (Dillenbourg & Tchounikine, 2007). Several empirical studies have provided evidence that collaboration scripts can enhance specific processes and outcomes of argumentation (Carmien et al. 2007; Kim et al, 2009; Kollar et al. 2006; Stegmann et al. 2007; Weinberger et al. 2007).

In general, the design of the collaboration script can be distinguished at the macro level and the micro level of collaboration (Fischer et al. 2007). The macro level of collaboration deals with the organizational issues of collaborative learning, while the micro level of collaboration relates to designing a specific activity for learners. With respect to collaboration script design, Dillenbourg and Hong (2008) suggested 'integrated scripts' that combine the macro level with a series of structured activities for groups and the micro level with learning tasks for individuals. The collaboration script may also aim to support specific components of collaborative learning, such as content-related support (epistemic script) or activity-related support (social script). Weinberger et al. (2007) showed that the epistemic script impeded the individual acquisition of knowledge, while the social script contributed to the individual acquisition of domain-specific knowledge. Apart from the general effects of collaboration scripts, collaboration script components can be very specific.

In this regard, not all collaboration scripts are necessarily effective. If collaboration scripts are too rigid and detailed, they can reduce cognitive processes and motivation. The term 'over-scripting' has been used to explain negative effects of collaboration scripts. To what extent over-scripting occurs may depend heavily on the internal script (Carmien et al. 2007; Kim et al. 2009). The 'internal script' refers to learners' prior knowledge and skills related to the learning task, while 'external script' describes the pedagogical scenario related to the learner activity (Dillenbourg & Jermann, 2007; Haake & Pfister, 2007; Kim et al. 2009; King, 2007; Kollar et al. 2006). Carmien et al. (2007) and Kim et al. (2009) described the complex interplay between the internal script and the external script in constructing collaborative knowledge. However, Stegmann and colleagues (2011) recently reframed over-scripting according to concepts of internal and external scripts. They suggested potential interferences between internal and external scripts in cognitive and motivational aspects. That is, the degree of scripting was found positively to affect cognition, but negatively affected motivation. This negative effect on motivation does not seem to be influenced by the internal script, but just the fact that there is a script. Even the best script does not foster learning if learners are not motivated to activate or use it (Stegmann et al. 2011). Bandura's self-efficacy has important implications with regard to motivation (Schunk, 1991). The basic principle of self-efficacy is that learners are likely to engage in activities, to the extent that they perceive themselves to be competent at those activities. Accordingly, the effects of collaboration scripts need to be examined from motivational aspects as well as cognitive aspects.

To account for these multiple aspects (micro vs. macro, content-related vs. activity-related, internal vs. external, cognitive vs. motivational) associated with collaboration scripts without risking oversimplification, we need to adopt a more comprehensive approach (Ludvigsen & Mørch, 2007). The learning in activity theory encompasses not a simple knowledge transmission, but continuing transformation processes where learners externalize and internalize their own

thoughts through languages or symbols within the socio-cultural context (Nardi, 1996a). Activity theory as such helps holistic design of the social process of learning (Zurita & Nassbaum, 2007) and offers a set of perspectives on human activity in collaborative knowledge creation. Furthermore, the activity theory notion that human activities and learning originate from the mediation of tools is enough to justify the development of collaboration scripts as instructional tools, while contradictions as the driving force of change and development provide a good rationale for argument supports.

From this perspective, the aim of study is to develop collaboration scripts for argumentation based on activity theory, and to analyze their effects.

1. In CSCL, how can collaboration scripts for argumentation be developed based on activity theory? Researchers will derive and refine the design principles from activity theory by design-based research (DBR). DBR allows researchers and educators to understand how students learn and design innovative learning environments based on previous researches (Ludvigsen & Mørch, 2007).

2. In CSCL, what influences do collaboration scripts for argumentation have on argumentation competence? To verify the effects in the cognitive aspect, researchers will examine how different types of external scripts and different levels of internal scripts influence learners' argumentation competence. Argumentation competence includes the quality of single arguments as well as the quality of argumentation sequences (Stegmann et al. 2007; Weinberger & Fischer, 2006).

3. In CSCL, what influences do collaboration scripts for argumentation have on self-efficacy in argumentaion? Self-efficacy is defined as "the conviction that one can successfully execute the behavior required to produce the outcome" (Bandura, 1977, 193). The effects of self-efficacy beliefs on cognitive processes positively predict performance beyond prior performance and ability (Bandura & Locke, 2003; Schunk, 1991). Thus, researchers will compare with the pre-test and post-test results for self-efficacy.

4. In CSCL, what factors to influence the collaborative learning processes and outcomes? In the area of CSCL research, interests have increasingly shifted from the collaborative learning outcomes towards the analysis of the collaborative learning processes. This shift shows as attempts to understand the nature of collaborative learning and to identify interactional features (Arvaja, 2011). Therefore, researchers will identify the factors that influence the collaborative learning processes and outcomes through survey.

Design Frameworks of Collaboration Scripts for Argumentation Based on Activity Theory

A fundamental tenet of activity theory is that a view of consciousness is central to a depiction of activity (Nardi, 1996a). In general, 'consciousness' means the human mind, and 'activity' implies the interaction of a human being with his or her external objects. However, activity theory considers activity and consciousness to be a unity, as consciousness is formed through significant social activities (Nardi, 1996b; Vygotsky, 2000). Therefore, learning is not merely individual activity, but a process where individual learners participate and interact with each other to create knowledge in a socio-cultural context. This critical feature of activity theory becomes *'the principle of collaboration'* in designing the collaboration script. According to the principle of collaboration, the collaboration scripts must help learners to participate, alternately, at the individual, dyad, group, and class levels, because it is difficult to share objectives in learning environments with reciprocal activities (Carmien et al. 2007; Dillenbourg & Hong, 2008). Additionally, as CSCL is a process where learners continue to collaborate, it is necessary to give learners interdependency. For this purpose, the collaboration script must offer social awareness for learners to improve their identity as members of a learning community, responsibility, and intimacy (Kim et al. 2000; Lee, 2003; Weinberger et

al. 2007; Yamagata-Lynch, 2001).

Second, learning in activity theory is not a simple knowledge transmission, but dynamic transformation from externalization to internalization in a socio-cultural context (Nardi, 1996b). Based on the internalization and externalization processes of activity theory, collaboration scripts must support communication not only from individual cognitive aspects, but also from socio-cultural aspects. This characteristic suggests *'the principle of communication'* in designing the collaboration script. According to the principle of communication, the collaboration scripts should be designed to help learner activities to benefit the cognition of others, facilitate common understanding, and promote sharing of artifacts (Beers et al. 2005; Fischer et al. 2007; Kim et al. 2008; Weinberger et al. 2007). Collaboration scripts should also clarify the mutually agreed-upon objectives of agreement so that learners can negotiate meaning with others (Beers et al. 2005; Fischer et al. 2007; Kwon, 2008; Nussbaum, 2008), and design the activities and tools to help learners internalize argumentative knowledge and skills (Beers et al. 2005; Nardi, 1996b; Vygotsky, 2000; Weinberger et al. 2007).

Third, mediation is a primary feature of activity theory; that is, all human experience is shaped by tools and sign systems (Nardi, 1996a). The tools here expand the learner's capability as the subject of the activities, and mediate interactions between the learner and the learning objective. Additionally, the notion that human activities and learning originate from the mediation of tools is enough to justify the development of the collaboration script as instructional scaffolds. This characteristic becomes *'the principle of coordination'* in designing the collaboration script. Therefore, collaboration scripts must provide structured activities, distribute roles (Kobbe et al. 2007; Kollar et al. 2006), visualize activity sequences and context (Dillenbourg & Hong, 2008), and construct flexible environments by face-to-face settings (Dillenbourg & Jermann, 2007; Fischer et al. 2007; Haake & Pfister, 2007; Wecker & Fischer, 2007).

Last, in activity theory, contradictions are the driving force of change and

development. Contradictions generate conflicts, but also facilitate attempts to change an activity (Engeström, 2001). This characteristic suggests *'the principle of contradiction'* in designing collaboration scripts for argumentation. According to this principle, scripts should allow learners to share disagreeing opinions, coordinate conflicts from various viewpoints, and create collaborative knowledge (Engeström, 2001; Kirschner & Erkens, 2006). The tasks for argument activities should suggest ill-structured problems with multiple viewpoints and solutions (Munneke et al. 2007; Schwarz et al. 2003; Stegmann et al. 2007), and trigger conflicts by forming dyads of learners with opposite opinions (Dillenbourg & Hong, 2008; Kim et al. 2009; Pang, 2009).

On the other hand, a collaboration script for argumentation based on activity theory can be reconceptualized as an activity system (Kobbe et al. 2007; Kollar et al. 2006). The components of collaboration scripts for argumentation as an activity

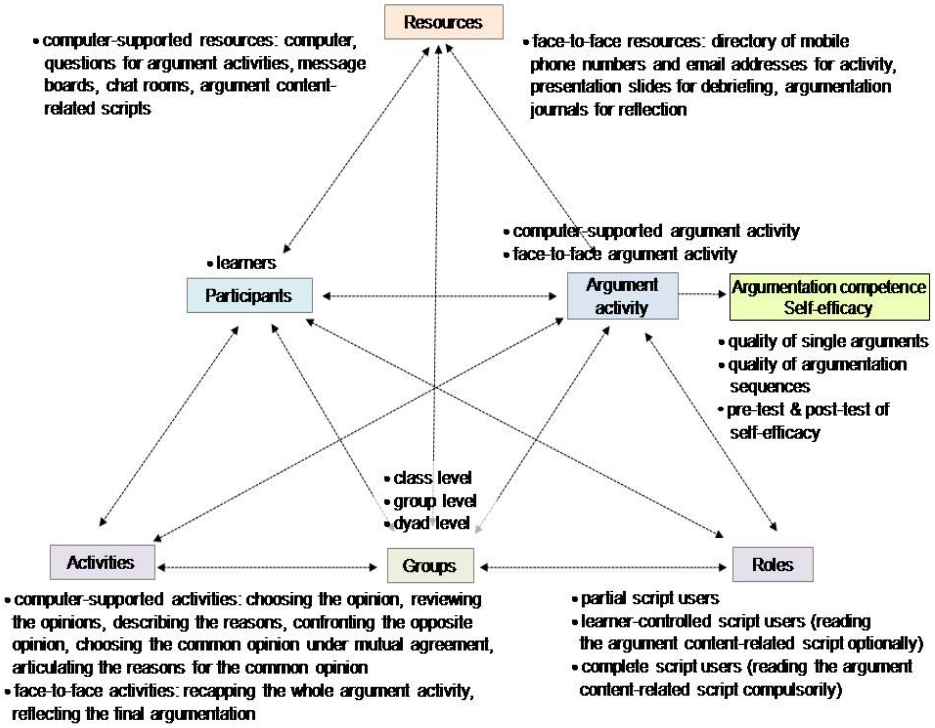

Figure 1. Components of collaboration scripts for argumentation as an activity system

system are as follows: the 'object' is 'argument activity,' the 'outcome' is 'argumentation competence,' and the 'subjects' are 'participants' involved in the process of knowledge creation as individual and collaborative learners. The 'community' of activity systems is made up of 'groups,' learning communities with shared objectives, which include dyad, group, and class levels. The 'mediating artifacts' are 'resources' that include not only computers as physical resources for learners to use to carry out the learning tasks, but also computer-supported and face-to-face artifacts, which include cognitive and social resources. 'Rules' guide the 'activities' of the participants in computer-supported and face-to-face settings, with explicit and implicit limits and supports. 'Division of labor' allocates the 'roles' for relations and activities among participants. A detailed list of components of collaboration scripts for argumentation is shown in Figure 1.

Methods

Processes of DBR

The first collaboration scripts for argumentation were developed based on the socio-cognitive conflict paradigm. However, learners pointed out from 1st scripts the unfamiliarity of the interface, the overload of the argument activities, and the inconvenience of the argument activities by dyads. To address these issues, researchers changed the interface by hiding unused functions and using emoticons to promote friendly environments. Besides, researchers provided demo video clips of the argument activities to reduce the overload, and redesigned group argument activities to simple message boards.

Then, as for the newly developed 2nd scripts, learners pointed out the inconvenience of asynchronous message boards, lack of collaboration mode supports and internalization supports. Therefore, researchers added synchronous

chatting rooms in the design, and activated on-line user list and instant messaging function to support collaboration support. Besides, researchers added content-related script evaluation and self-evaluation activities to support internalization. Through these iterative cycles, the refined design and implementation principles are as follows: (See Table 1).

Table 1. Design and implementation principles of collaboration scripts for argumentation (Kim, 2012)

Design principles	Sub-design principles	Implementation principles	Implemented contents	Implemented scripts
Contradiction principle	Conflict triggering support	- Task distribution - Group formation	Provide the multiple-choice questionnaire that includes ill-structured problems with various viewpoints and solutions	1st -2nd-3rd
			Organize dyads who choose opposite opinions	
Communication principle	Externalization support	- Task distribution - Group formation	Choose and review the opinion	1st -2nd-3rd
			Describe the reasons for the opinion	
			Choose a common opinion after negotiation	
			Present the individual and collaborative arguments	
	Mutual agreement support	- Group formation - Task distribution - Visualization	Provide the dyad argument activity	1st -2nd-3rd
			Provide the asynchronous message board	1st -2nd
			Provide the synchronous chat room	3rd
			Provide the percentages of each opinion in the same group	1st -2nd-3rd
	Internalization support	- Task distribution	Provide the argumentation journal in a face-to-face setting	3rd
			Provide the content-related script evaluation and self-evaluation	3rd
Coordination principle	Sequential support	- Sequencing - Visualization	Provide sequential argument activities	1st -2nd-3rd
			Provide the sequential activity diagram	2nd-3rd
	Integrated support	- Script support	Provide compulsorily the content-related script	1st -2nd-3rd
	Flexible support	- Script support	Provide optionally the content-related script	1st -2nd-3rd
			Provide the blended script	3rd
Collaboration principle	Social awareness support	- Task distribution - Awareness support	Introduce the weekly activity	1st -2nd-3rd
			Post the researcher's emotional reflective journal	2nd-3rd
			Provide the peer review	3rd
			Activate the online user list	3rd
			Activate the instant messaging function	3rd

CSCL environment

The CSCL environment used MOODLE (Modular Object Oriented Dynamic Learning), an open-source software that allows researchers to redesign learning activity sequences through cyclical and iterative procedures. In particular, MOODLE 's LAMS (Learning Activity Management System), a sequential learning platform, provides intuitive visual tools to organize learning activity sequences. Using LAMS, collaboration scripts for argumentation were developed.

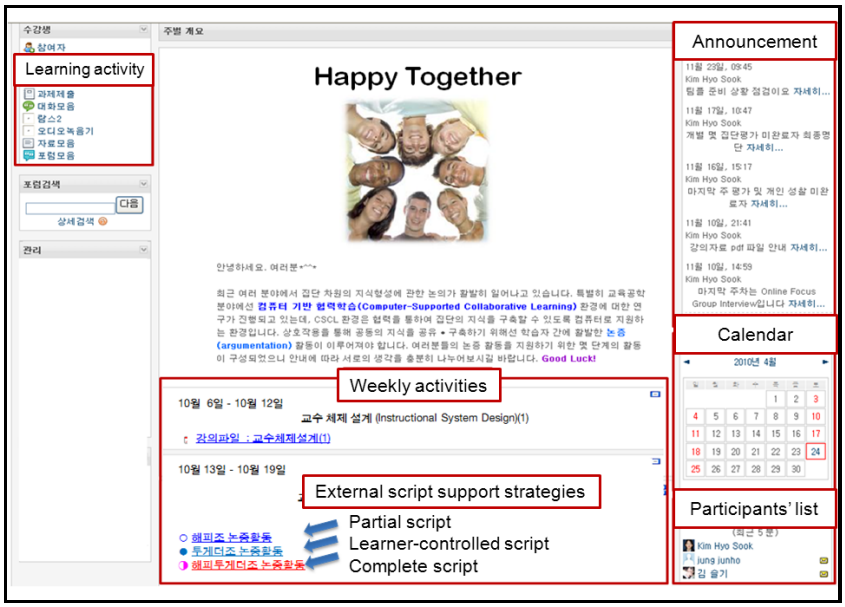

Figure 1. Screenshot of the CSCL environment using MOODLE

Participants

The participants consisted of 72 undergraduate students (females (N = 41), males (N = 31)), enrolled in the Educational Technology course at P-college located in Seoul. They were divided into two groups (36 for each) according to their internal script levels (t = 8.34, $p < .05$), and randomly assigned to one of three

external scripts (24 for each) ($F_{2, 69} = .04$, $p > .05$). Prior to collaborative learning, the randomization of participants on computer experience ($F_{5, 66} = .63$, $p > .05$) and collaboration propensity ($F_{5, 66} = .24$, $p > .05$) was successfully controlled using the 5-point Likert scale tests.

Variables and measures

Independent variables were *levels of the internal script* that measured and categorized participants' prior knowledge on argumentation using a multiple-choice test (Cronbach's $\alpha = .64$) and the argumentation essay. The essay was assessed by the rubric focused on single arguments. The other independent variables were *types of the external script,* such as the partial script (with an activity-related script, without a content-related script), learner-controlled script (with an activity-related script, with an optional content-related script), and complete script (with an activity-related script, with a compulsory content-related script). External scripts would be designed to consider levels of collaboration and components of collaboration scripts (Kim et al. 2009).

The dependent variable was *argumentation competence,* which included the quality of single arguments and argumentation sequences. Focusing on *the quality of single arguments* emphasizes the individual aspect, such as the frequency and fidelity of the claim, grounds, and qualifications, while focusing on *the quality of argumentation sequences* emphasizes the collaborative aspect, such as the frequency and fidelity of the interactive sequences-arguments, counterarguments, and integration-and mutual openness. The quality of single arguments was evaluated by quantifying the individual messages in the response phase and reflection phase, while the quality of argumentation sequences was evaluated by quantifying the collaborative argument messages in the conflict phase. This argumentation competence was assessed by argumentation rubrics that strongly based on previous studies by Stegmann et al. (2007) and Yang et al. (2009). These rubrics used qualitative statements for

individual and group execution standards. These statements adopted a 5-point rating scale (i. e., 1 = irrelevant to the argument content/simple statement of the content, 2 = relevant to the argument content/unclear statement, 3 = focused on the issues of the argument content/can be understood by others, 4 = well approaching the argument content/concrete and clear and can be understood by all, 5 = recognizes secondary issues of the argument content/take position with clear explanation). The inter-rater agreement on 30% of the data was .75 (Cohen's k).

The other dependent variable was *self-efficacy in argumentation*. To examine their self-efficacy, the pre-test and post-test were conducted by using the 5-point Likert scale responses. Besides, *factors influencing collaborative learning processes and outcomes* were surveyed by using a open-ended question. To analyze survey data, researchers used the message analysis framework that Oh (2008) suggested concerning the components of the collaboration script.

Procedure

The duration of the experiment was eight weeks. In week one, participants were introduced to collaboration scripts for argumentation in CSCL and executed internal script level tests. In week two, the computer experience test, the collaboration propensity test, the self-efficacy pre-test, and MOODLE registration were conducted. In weeks three and four, participants went through exercise activities and a preparatory experiment. In weeks five and seven, the real test was done. For example, the question for the argumentation was; "How do you think the high-tech era of advanced information and communication technology has influenced the educational ministry? The self-efficacy post-test and survey were conducted in week eight.

Results

RQ1. Developments of collaboration scripts for argumentation

The latest version of collaboration scripts for argumentation was divided into five phases based on ArgueGraph, and the progression from phase to phase was automatized. Based on the implications of a previous study (Kim et al. 2009), blended script was developed to consider the flexibility of the collaboration script.

The response phase is for individual activity in a computer-supported setting. Each participant responds to a multiple-choice questionnaire (see Figure 2 ①). According to the principle of contradiction based on activity theory, the questions do not have right and wrong answers, but are rather designed to reflect various viewpoints and solutions. The activity diagram also allowed participants to discern completed or uncompleted activities in term of color and figure coding (Kollar et al. 2006) (see Figure 2 ②).

The review phase is for group activity in a computer-supported setting. Based on the principle of communication, participants were allowed to access the percentages of each opinion in the same script group (see Figure 3). Besides, according to the

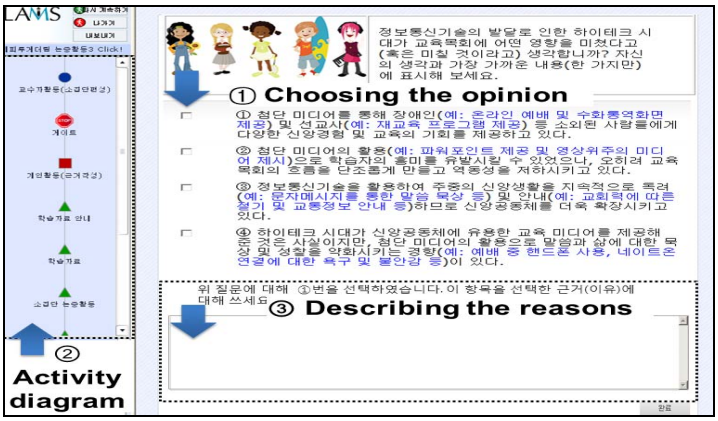

Figure 2. The response phase

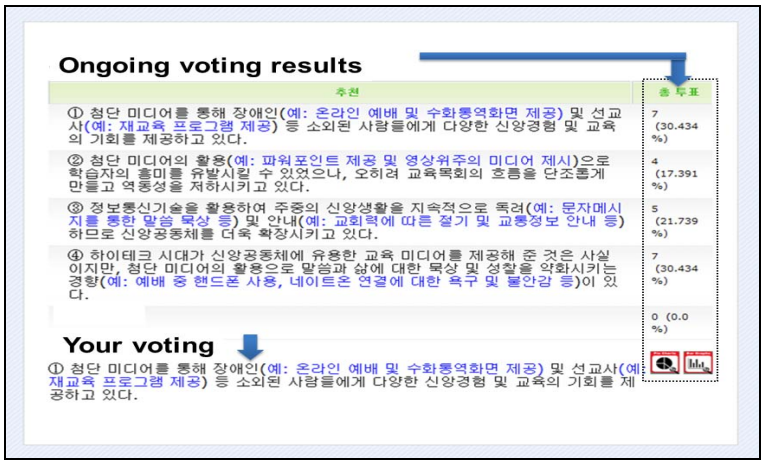

Figure 3. The review phase

principle of communication, participants described the reasons for the opinion that they chose (see Figure 2 ③).

The conflict phase is for dyad activity in a computer-supported setting. According to the principle of contradiction, researchers formed dyads of participants with opposing opinions and reorganized dyads in every experiment to reflect participants' answers. To support externalization based on the principle of

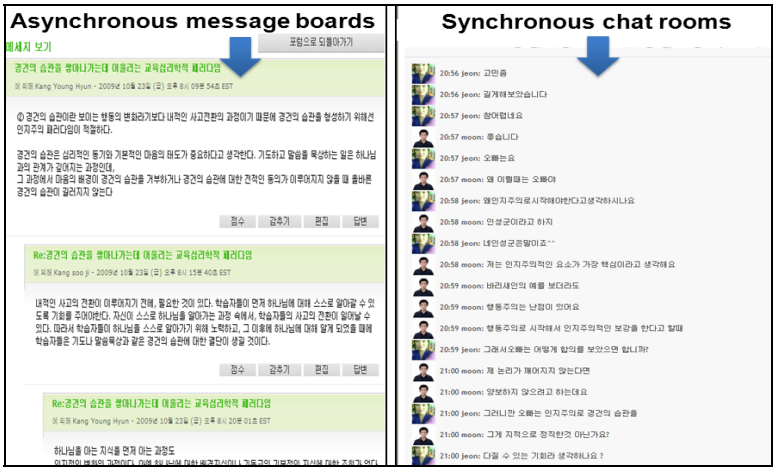

Figure 4. The conflict phase

communication, participants were allowed to choose freely from synchronous chat rooms and asynchronous message boards to build dyad argumentation (see Figure 4). Based on the principle of coordination, argument content-related scripts were optional (flexible support) or compulsory (integrated support) (see Figure 5). Again, for externalization based on the principle of communication, participants selected a single answer after mutual agreements and wrote common reasons.

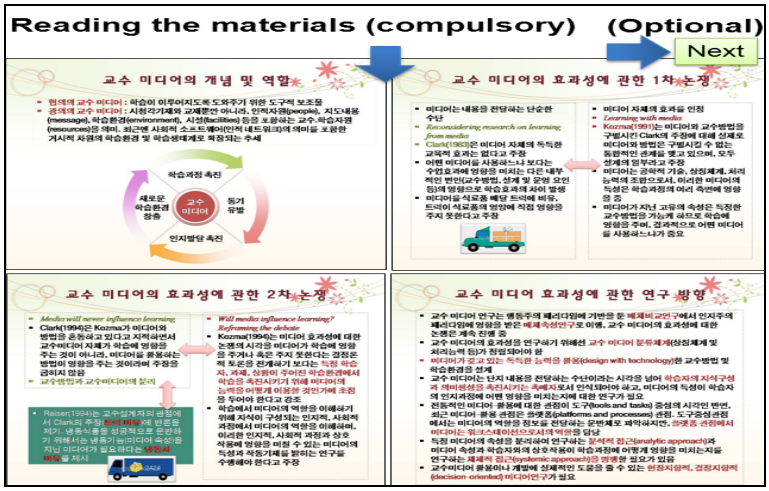

Figure 5. An example of argument content-related script

The recap phase is for class activity in a face-to-face setting. For flexible support based on the principle of coordination, collaboration scripts for argumentation were expanded in a face-to-face discussion. To support internalization and externalization based on the principle of communication, researchers presented a recap of the learners' individual and collaborative arguments, suggested comments, and asked them to clarify their opinions.

The reflection phase is for individual activity in a face-to-face setting. To support internalization based on the principle of communication, participants were guided to choose a final opinion for the question, and write argumentation journals.

Collaboration scripts for argumentation were designed so that participants would

alternate between individual and group activities based on the principle of collaboration (Carmien et al. 2007; Dillenbourg & Hong, 2008). In this process, participants were provided with tools (e.g., presence of others) to enhance their social awareness (Jang, 2005; Lee, 2003; Yamagata-Lynch, 2001). Activity flows by collaboration scripts is described in Figure 6.

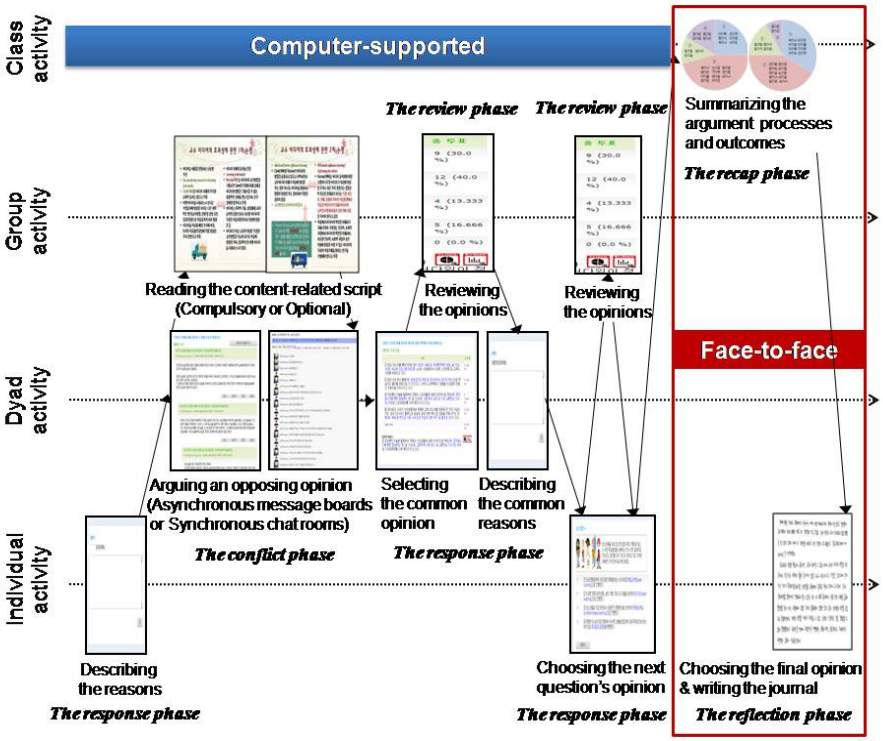

Figure 6. Activity flows by collaboration scripts for argumentation

RQ2. Effects of collaboration scripts for argumentation on argumentation competence

Quality of single arguments

The results of single arguments by internal scripts before and after the argument activities are shown in Table 2.

Table 2. Results of single arguments by internal scripts before and after the argument activities (n = 36)

	High internal script		Low internal script	
	Before	After	Before	After
Experiment 1	7.69 (2.10)	10.22 (2.09)	6.81 (2.01)	8.36 (2.14)
Experiment 2	7.81 (1.94)	10.64 (2.66)	6.42 (1.99)	8.75 (2.22)
Experiment 3	8.47 (1.93)	11.72 (2.11)	6.94 (2.14)	9.39 (2.23)
Total	9.43 (2.62)		7.78 (2.38)	

To analyze the effects of internal scripts on the quality of single arguments, a repeated-measures ANOVA was conducted. The results showed significant differences between the two groups by internal scripts ($F_{1, 425} = 64.20$, $p < .05$) and within each group before and after argument activities ($F_{5, 425} = 32.57$, $p < .05$). Consequently, collaboration scripts for argumentation had positive effects on the quality of single arguments regardless of whether internal script levels were high or low, and the higher the internal scripts, the higher the quality of single arguments.

Besides, the results of single arguments by external scripts before and after the argument activities are shown in Table 3.

Table 3. Results of single arguments by external scripts before and after the argument activities (n = 24)

	Partial script		Learner-controlled script		Complete script	
	Before	After	Before	After	Before	After
Experiment 1	7.50 (1.69)	9.25 (2.15)	7.54 (1.53)	9.50 (2.02)	6.71 (2.79)	9.13 (2.74)
Experiment 2	7.38 (1.61)	9.88 (2.52)	7.00 (1.96)	9.67 (2.58)	6.96 (2.60)	9.54 (2.83)
Experiment 3	7.96 (2.16)	10.88 (1.87)	7.63 (2.10)	10.63 (2.72)	7.54 (2.30)	10.17 (2.73)
Total	8.81 (2.38)		8.66 (2.53)		8.34 (2.94)	

To verify the effects of external scripts on the quality of single arguments, a repeated-measures ANOVA was conducted. The results revealed no significant differences among the three groups with different external scripts ($F_{2, 424} = 1.56$, $p > .05$). However, there were significant differences within each group before and after the argument activities ($F_{5, 424} = 28.44$, $p < .05$).

Quality of argumentation sequences

To analyze the effects of internal scripts on the quality of argumentation sequences, one-way ANOVA was conducted. The results showed significant differences between the two groups by internal scripts in Experiment 1 ($F_{1, 70} = 22.09$, $p < .05$), Experiment 2 ($F_{1, 70} = 12.14$, $p < .05$), and Experiment 3 ($F_{1, 70} = 6.01$, $p < .05$). As seen in Table 4, the means of those with low internal script continuously improved, and the gap between the means of the two groups were reduced remarkably as the experiments were repeated.

Table 4. Results of the one-way ANOVA on argumentation sequences by internal scripts (n = 18(dyads))

	Source	*Mean*	*SD*	*F*	*p*
Experiment 1	High internal script	8.81	1.06	22.09	.00**
	Low internal script	7.33	1.55		
Experiment 2	High internal script	9.11	1.01	12.14	.00**
	Low internal script	8.17	1.28		
Experiment 3	High internal script	8.94	.98	6.01	.01**
	Low internal script	8.28	1.30		

*$p < .05$. **$p < .01$.

Furthermore, to examine the effects of external scripts on the quality of argumentation sequences, Kruskal-Wallis test was carried out. As shown in Table 5, there were significant differences among the three groups by external scripts in

Experiment 1 ($\chi^2 = 6.41$, $p < .05$) and Experiment 2 ($\chi^2 = 7.18$, $p < .05$), while there was none in Experiment 3 ($\chi^2 = 4.54$, $p > .05$).

Table 5. Results of the Kruskal-Wallis test on argumentation sequences by external scripts (n = 12(dyads))

	Source	*Mean*	*SD*	χ^2	*p*
Experiment 1	Partial script	7.50	1.22	6.41	.04*
	Learner-controlled script	8.58	1.53		
	Complete script	8.13	1.62		
Experiment 2	Partial script	8.17	1.24	7.18	.03*
	Learner-controlled script	9.08	.88		
	Complete script	8.67	1.40		
Experiment 3	Partial script	8.42	.88	4.54	.10
	Learner-controlled script	8.92	1.28		
	Complete script	8.50	1.35		

*$p < .05$. **$p < .01$.

RQ3. Effects of collaboration scripts for argumentation on self-efficacy

The pre-test and post-test results for self-efficacy by the internal scripts and external scripts are shown in Table 6.

To analyze the effects of collaboration scripts for argumentation on self-efficacy, a repeated-measures ANOVA was conducted. As a result, there were meaningful differences between pre-test and post-test ($F_{1, 137} = 4.13$, $p < .05$) and among the groups ($F_{5, 137} = 2.41$, $p < .05$).

In sum, collaboration scripts for argumentation had positive effects on learners' self-efficacy in argumentation, and learners with higher internal scripts had better self-efficacy.

Table 6. Pre-test and post-test results for self-efficacy by the internal scripts and external scripts (n = 12)

	High internal script		Low internal script	
	Pre-test	Post-test	Pre-test	Post-test
Partial script	3.06 (5.83)	3.29 (3.99)	2.92 (4.98)	3.12 (4.36)
Learner-controlled script	3.17 (6.14)	3.25 (4.19)	3.02 (4.85)	3.29 (4.89)
Complete script	3.45 (6.26)	3.36 (7.14)	2.96 (4.58)	3.15 (4.24)

RQ4. Factors influencing collaborative learning processes and outcomes

Survey data were categorized by the message analysis framework, and the results are as follows.

Participants. With regard to the external characteristics of the collaborative learner (e.g., age, sex, and grade), the degree of diligence of the partner affected more on argument activities than the external characteristics of the participants (P-1).

Object/outcome. With respect to object or outcome, the argument activity was reportedly helpful in strengthening both domain-general knowledge (O-1) and domain-specific knowledge (O-2).

Resources. As for the communication tools of two types used in the dyad activity, this had more to do with personal preference than internal scripts (R-1/R-2). Besides, in the argument content-related scripts provided, participants preferred the pros-and-cons types so that they could counter the arguments of their counterparts. Participants reported that the content-related script was more useful when specific cases were provided rather than general or abstract concepts (R-3).

Groups. Participants were intended to be formed dyads with opposite opinions to trigger argumentation, but in some dyads, participants shared similar opinions, as we could not manipulate participants' opinions. Participants had more

dynamic argumentation when they disagreed than when they agreed (G-1/2).

Activity/role. The purpose of collaboration scripts for argumentation is to provide structured activities for participants' interaction, and participants gave very positive responses about argument activities by collaboration scripts (A-1/2/3). However, most participants felt it burdensome to spend a lot of time in argument activities (A-4). Examples of representative opinions are shown in Table 7.

Table 7. Examples of representative opinions

Category	Opinions
Participants	(P-1) "It was difficult when my partner seemed to become bored with the process."
Object/ outcome	(O-1) "I didn't have enough time for consideration before I chose an opinion, but I was able to clarify my own claims and grounds through the argument activity." (O-2) "The best part was that I learned to have deeper thoughts on the design of effective learning environments and to build single arguments through the argument activities."
Resources	(R-1) "I found argumentation using message boards helpful because I could easily follow the activity flow and see all the messages on one page." (R-2) "I very much liked using both message boards and chat rooms." (R-3) "I received reliable supplementary materials in the argumentation processes and clarified the things that I didn't fully understand from my partner's counter-argument; I also clarified my own argument."
Groups	(G-1) "I was able to express a broader view and range of overall thinking through the argument activity that I had with others who had disagreeing opinions." (G-2) "I was coupled with a person who had the same argumentation competence as I did, but we disagreed, which made me quite confident in my opinions."
Activity / role	(A-1) "It was a useful experience for me to participate in argumentation with peers of my own level in online environments." (A-2) "I was able to confirm the status of each activity phase through the activity diagram. I also very much liked having a second chance to revise my opinion after I saw the percentages of the other opinions for each question." (A-3) "I could recognize my learning processes from the activity diagram, which was handy in finishing the steps one by one." (A-4) "Argumentation was useful but consumed much time. I had difficulty fixing meeting time with partner."

Discussion

On the basis of the results obtained from developing the collaboration scripts for argumentation and analyzing their effects, we can discuss the following:

With regard to the development of collaboration scripts for argumentation, the final scripts were developed through iterative design cycles. The design of learning environments that enhance rich interactions must not only apply principles derived from preliminary studies but also integrate through ongoing dialogue with educational fields.

With respect to the effects of internal scripts on the quality of single arguments, there were effective for everyone with different internal script levels. Participants with high internal scripts especially showed greater improvement, which replicates the findings of Kim et al. (2009). On the other hand, there were no significant differences among groups with external scripts. When group averages were compared, the complete script group showed the greatest improvements at first, as the script included an content-related script, but in following experiments, they did not show any significant improvement. As Stegmann et al. (2011) pointed out, this result may be due to reduction of the learners' autonomy rather than malfunction scripts. The partial script group, however, steadfastly and continuously improved the quality of single arguments, which supports the results of Kim et al. (2009).

With regard to the effects of internal scripts on the quality of argumentation sequences, there were significant differences between the two groups with different internal scripts, while in following experiments, the gap between group averages decreased. Besides, there were significant differences among the three groups by external scripts in Experiments 1 and 2, but none in Experiment 3. Repetition of the experiments resulted in a decrease in the average, and differences between the experiments were less significant. These results imply that collaboration scripts have some robust beneficial effects, but structured activities can cause negative effects. Besides, negative effects may be due to collaboration load rather than over-

scripting in the cognitive aspect.

With respect to the self-efficacy, collaboration scripts for argumentation had positive effects on learners' self-efficacy, and learners with higher internal scripts had better self-efficacy. When group averages were compared, learners with the high internal script levels who were provided the complete script showed the greatest improvements in the pre-test. However, in the post-test, the average of this group decreased. We can infer from this result that a high degree of scripting has a negative effect on motivation (Stegmann et al. 2011).

With respect to the factors influencing collaborative learning processes and outcomes, collaboration scripts of argumentation have been proved to vary in their effects by group characteristics, material types, scripting periods, et cetera. These results support the prior research findings. Schwarz et al. (2003) demonstrated that the effects of argumentation support tools vary depending on the learning context. Schellens et al. (2007) also found that different results depending on different conditions such as whether the communication was synchronous or asynchronous, or whether the supporting period was an hour or a semester. Therefore, when scripting learner's interaction in CSCL, researchers should make the scripts adaptable to different contexts.

Conclusion

Argumentation is a central concern in collaborative learning. In this study, researchers sought to develop collaboration scripts as instructional tools and resources to support argumentation. For the integrated design, researchers refined the design and implementation principles based on activity theory. Using MOODLE's LAMS, collaboration scripts for argumentation were developed based on the ArgueGraph, and reconceptualized the collaboration script as an activity system. To verify their effects, participants were grouped by internal scripts, and randomly allocated to the partial script, the learner-controlled script, or the

complete script. Then, researchers analyzed argumentation competence and self-efficacy, and identified factors influencing collaborative learning processes and outcomes. The following conclusions can be drawn:

First, learners' internal scripts are proven to be a critical factor to determine the dimensions, degrees, and duration of improvement in argumentation competence. Accordingly, if we reduce the differences between the two groups by providing the group with low internal script levels with an additional opportunity to engage in collaborative learning, we might be able to expect synergy of more dynamic collaboration.

Second, the effects of external scripts varied with the learners' internal scripts and scripting periods. As Carmien et al. (2007) pointed out, learners with different internal scripts can be complemented only by different external scripts. Hence, researchers should continuously explore the interactions of various factors to complement and promote learners' internal scripts. On the other hand, with respect to the scripting types and supporting periods, complete scripts better address the needs for short-term learning objectives, while partial scripts serve a better purpose as far as long-term objectives are concerned.

Third, self-efficacy is an extremely important factor in learning (Schunk, 1991). Therefore, researchers need to design collaboration scripts to help learners maintain their learning motivation. In order to do so, researchers should continuously investigate the interplay between internal and external scripts, as well as intrinsic and extrinsic motivation.

Last, productive interaction needs to be understood not only as sequences of interaction but as part of a natural context of activities (Ludvigsen & Mørch, 2007). In this respect, our study is remarkable that interactions among multiple variables are well captured to be highlighted in the context of the development of collaboration scripts in CSCL, in an effort to combine DBR and experimental study. Additionally, LAMS provides a useful environment that not only facilitates the designing of collaboration scripts but also helps implement them in any existing learning environments.

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