

Development of Design Principles of Group Awareness Tool for Facilitating Computer-supported Collaborative Argumentation

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ABSTRACT

As one of the forms of collaborative learning, collaborative argumentation can improve students' argumentation skills, promote effective content learning and cultivate critical thinking. Especially in the field of Computer-supported Collaborative Learning (CSCL), such as conflicts between group members, free-riding behavior, and unequal participation occur frequently. At the same time, in the CSCL environment, it is difficult to coordinate one's actions with other group members' actions. These problems are mainly caused by learners who cannot obtain group awareness information about accompanying learners and the current group. Therefore, this study according to the previous research, the initial design principles and initial specific guidelines for the group awareness tool were identified. After that, three educational technology experts reviewed the initial design principles and guidelines. The modified specific guidelines were applied to the two-week classroom teaching of 45 first-year students in a class. In addition, a learners' response survey was conducted on the students who actually participated in the computer-supported collaborative argumentation activities. Finally, the results of questionnaire surveys (n=45) and interviews (n=5) were analyzed, and the final specific guidelines were developed. According to the research results, collaborative argumentation based on group awareness tool solves the problem that general collaborative argumentation activities can't obtain timely information on the cognitive, behavioral, and social awareness of accompanying learners and the current group study situation. It can continuously maintain their study motivation and promote interaction among learners to improve the quality of computer-supported collaborative learning.

KEYWORDS

Computer-Supported Collaborative Argumentation, Group Awareness, Group Awareness Tool, Interaction Among Learners

1. INTRODUCTION

Argumentation is the active discussion conducted by people holding different opinions, and is a strategy for learning how to solve problems and a method for assessing problem-solving abilities (Jonassen & Cho, 2011; Sampson & Clark, 2009). Argumentation is commonplace in all aspects of our lives. The forms of argumentation activities can be factionalized into individual and collaborative argumentation. In collaborative argumentation, learners can enjoy and assess their opinions and then expand and develop their own proposals[1].

Collaborative argumentation activity has teaching value in improving students' argumentation skills, effective analyzing skills and social skills development. In the collaborative argumentation activity, learners can master and internalize knowledge, which means evolving from knowledge structure to cognition structure (Nussbaum, Sinatra, & Poliquin, 2008)[2]. On the other hand, the teaching value

of collaborative argumentation in learners' communication capacity and the development of critical thinking capacity has been proved (Jeong, 2015; Lee, Choi, & Bae, 2002; Lee, Park, & Kim, 2016).

However, although the research results show that the collaborative argumentation holds significance, there are difficulties in applying it to the actual teaching field. The main reasons can be roughly branched into three levels[3]. Firstly, students' uneven participation is a problem worth discussing (Lee et al., 2016). In addition, in many cases, even if the time allocated for oral debate is extended, opinions remain cagey (Kwon, 2013). Thirdly, even if students can effectively construct argumentation, it is challenging for them to improve their knowledge through mutual communication. This is the critical issue with collaborative argumentation (Kwon, 2013; Lee & Yang, 2009; Seo, 2016).

In the current research, in order to solve the difficulty in application, the factors influencing the collaborative argumentation have been studied and multiple specific guidelines have been tried[4]. However, among collaborative argumentation activities and supporting research, most of them have geared the research towards a face-to-face environment. There are very few research endeavouring on the design and supporting methods of collaborative argumentation activity under the Computer-Supported Collaborative Learning (CSCL) environment[5].

If the interaction among learners is not conducted actively, the effect of collaborative study will decline to a large extent (Kwon, Liu, & Johnson, 2014). Although the above issues exist in the face-to-face learning environments, due to the lack of non-verbal cues such as actions and facial expressions, these issues are presented more prominently within the CSCL environment[6]. According to the study, providing the information of accompanying learners for online collaborative learners can promote interaction and is an essential means to improve the learning quality of CSCL (Janssen, Erkens, & Kanselaar, 2007; Janssen, Erkens, Kanselaar, & Jaspers, 2007; Jermann & Dillenbourg, 2008). During the collaborative study, only when learners can acquire information from the aspects of cognition, behavior, and society, can achieve good communicate with accompanying learners. The information is called group awareness information (Pifarré, Cobos, & Argelagós, 2014)[7].

There are very few group awareness tools that penetrate group awareness information from three aspects - cognition, behavior and society. In addition, although some group awareness tools have analyzed the learners' behaviors to a certain extent (such as login times and study time), they have not explored online study activity deeply and not conducted profound analysis on the process of study activity process[8]. This study has developed design principles and specific guidelines for computer-supported collaborative argumentation based on group awareness tool to address this research gap.

This study proposes the research theme on design principles for group awareness tool in computer-supported collaborative argumentation. The aims of this study can be divided into practical and theoretical levels[9]. Developed specific guidelines can solve the issues that occur during the course of computer-supported collaborative argumentation, the collaborative learning efficiency is not high due to insufficient group awareness information from accompanying learners. It is expected that the specific guidelines can help learners conduct practical computer-supported collaborative argumentation activities[10]. From the theoretical level, its purpose is to transfer the focus of group awareness tools in current research, which no longer focuses on the supervision and judgment of collaborative learning results but pays more attention to the online collaborative learning process. Then deep exploration and analysis on learners' behavioral modes will be carried out. This study addressed the following two research questions:

Q1. What are the design principles and specific guidelines for group awareness tool in computer-supported collaborative argumentation?

Q2. What are the responses of learners to group awareness tool reflecting the design principles and specific guidelines?

2. LITERATURE REVIEW

2.1. Computer-supported collaborative argumentation

In accordance with Walton's (2009) opinions, an argument can be divided into a dialectical argument and a non-dialectical argument. For example, the argument appearing during the activity of solving problems is non-dialectical[11]. On the contrary, lawsuits, seminars, medical conferences and other arguments belong to the dialectical argument.

Furthermore, according to Walton's (2009) study, the several components of argumentation include premise, conclusion and inference. Driver and colleagues (2000) mainly analyze this issue according to the differences of logistics and argumentation[12]. Argumentation draws a conclusion from the relevant principles in specific situations. Logistics is an inference without being limited by the context (Driver, 2000). The definition of argumentation by Golanics and Nussbaum (2008), argumentation is the process of composing critical thinking abilities and social interactions based on the constructivism study theory[13].

Therefore, the concept of computer-supported collaborative argumentation can be summarized as a collaborative learning activity that uses the computer as a medium to conduct discussions online, in which two or more learners come up with verify and criticize their proposals respectively and find the best solutions for issues discussed[14].

Collaborative argumentation can promote complicated critical thinking, which is manifested by the capacity of identifying, constructing, and assessing arguments (Fmino,2005). In addition, collaborative argumentation has major significance in the science and education field[15]. Inference and argumentation ability can help scientists deeply understand how to create, prove and assess (Sampson & Clark, 2009). collaborative argumentation can promote the development of critical thinking and let students adapt to scientific and cultural practice activities (Erduran & Jiménez-Aleixandre, 2008).

Especially in a computer-supported collaborative argumentation environment, it can provide learners with learning support based on technological means[16]. In this way, the time and space limitations of the interaction between learners can be expanded, deep cooperation can be enhanced, and the adjustment of learners' learning behaviors and reflective activities can be promoted (Koschmann, 1996; Stahl, Koschmann, & Suthers, 2006).

Although computer-supported collaborative argumentation has teaching values, it has not been actively applied to the actual teaching[17]. In order to effectively apply the computer-supported collaborative argumentation, we need to assess the difficulty in application.

Firstly, in collaborative learning, all members should undertake the common cognitive responsibility to study the process (Scardamalia, 2002)[18]. Secondly, because learners cannot organize high-level arguments very well, it is much more common to choose the initial solutions. The reason is that it is hard for learners to prove the rationality between proposals and evidence (Erduran, Simon, & Osborne, 2004; Jiménez-Aleixandre & Erduran, 2008; Sandoval, 2003; Sandoval & Millwood, 2005)[19]. Moreover, the goal of collaborative learning is collaborative knowledge building and common problem solving. The interaction among learners is one of the factors, which influence the collaborative learning effect (Jonassen & Kwon, 2001).

It can be seen from these current researches that interaction between learners in collaborative argumentation is significant[20]. If team members do not agree with the opinions or solutions raised by other team members, they need to negotiation and adjustment (Volet, Vauras, & Salonen, 2009). When the clues of social context such as body shape, voice and intonation, eyesight contact, and group integrity are insufficient, due to the decrease of learners' attention and motivation towards discussion and argumentation, the effect of collaborative argumentation may be hindered (Coffin & O'Halloran, 2009)[21].

From the social context of interaction between learners, the reason of ineffective or inefficient collaboration is due to the lack of group awareness (Janssen, Erkens, & Kanselaar, 2007; Jermann & Dillenbourg, 2008). Because in collaborative learning scenarios, awareness of partners' cognitive and social activities is a relevant variable, group awareness can help learners overcome the problems related to communication, participation, and coordination of group work (Carroll, Neale, Isenhour, Rosson, & McCrickard, 2003)[22]. Cognitive awareness focuses on the knowledge level of group members. Behavior awareness focuses on learners' behavior in the CSCL environment. Social awareness can promote mutual understanding among group members in order to develop a better learning group and solve problems together (Kreijns, Kirschner, & Jochems, 2003)[23].

Therefore, in computer-supported collaborative argumentation, learners need to perceive accompanying learners' cognitive, behavioral, and social information, so that they can overcome communication barriers with accompanying learners, promote interaction and improve the quality of collaborative argumentation activities ultimately[24].

According to Gross and colleagues (2005), group awareness means acquiring the information about team members, as well as the relevant information about the situation of group activities at present, so as to execute some task effectively. In addition, group awareness means acquiring the activity information of team members and activity space (Kimmerle & Cress, 2008)[25]. Group awareness can also be equal to the social presence (Gunawardena, Lowe, & Anderson, 1997), for social presence is defined as "perceiving the interactive partners" (Kreijns et al., 2003). The information perceived may come from the study progress of several group members, maybe the information reflecting the collaboration status of the whole group[26].

In the FTF (Face-To-Face) , group awareness can be acquired very easily. However, if team members are separated spatially, which means in CSCL environment, technical support is required if members want to acquire group awareness information. In conclusion, group awareness provides learners with their accompanying learners' cognitive information, behavioral awareness information, and social awareness information through technical support, inducing the mutual awareness among learners, promoting the interaction among learners and finally improving the effect of collaborative learning in the CSCL environment[27].

2.2. Group awareness

The difficulties in applying collaborative argumentation in teaching activities include the unbalanced participation of learners, and learners failing to organize high-level arguments, and cannot construct collaborative knowledge. It can be seen that the quantity and quality of interaction between learners play an important role in collaborative argumentation[28].

Although in current research, collaborative argumentation factors have been analyzed, and various instructing support methods for collaborative argumentation have been tried. From the social context of interaction between learners, the reason of ineffective or inefficient collaboration is due to the lack of group awareness (Janssen, Erkens, & Kanselaar, 2007; Jermann & Dillenbourg, 2008). Because in collaborative learning scenarios, awareness of partners' cognitive and social activities is a relevant variable, group awareness can help learners overcome the problems related to communication, participation, and coordination of group work (Carroll, Neale, Isenhour, Rosson, & McCrickard, 2003). Cognitive awareness focuses on the knowledge level of group members. Behavior awareness focuses on learners' behavior in the CSCL environment[29]. Social awareness can promote mutual understanding among group members in order to develop a better learning group and solve problems together (Kreijns, Kirschner, & Jochems, 2003).

Group awareness is information about group members' behavior, knowledge skills, and social activities in collaborative learning (Schmidt, 2002). According to Gross and colleagues (2005), group awareness means acquiring the information about team members, as well as the relevant information about the situation of group activities at present, so as to execute some task effectively. In addition,

group awareness means acquiring the activity information of team members and activity space (Kimmerle & Cress, 2008). Group awareness can also be equal to the social presence (Gunawardena, Lowe, & Anderson, 1997), for social presence is defined as “perceiving the interactive partners” (Kreijns et al., 2003)[30].

In conclusion, group awareness is to perceive what in the current situation, including activity information of members and environmental status information, such as whether group members are online or not, who are the active participants in the group discussion, and how the current situation is in solving the task. The information perceived may come from the study progress of several group members, maybe the information reflecting the collaboration status of the whole group. Group awareness can be divided into three types (Bodemer & Dehler, 2011), as shown in Table 1.

Table 1 Classification of Group Awareness

Classification	Explanation
Cognitive awareness	Paying attention to knowledge level of group members and know about group members’ understanding level of knowledge such as group members’ prior knowledge, interest, skills equipped,etc. (Bodemer, 2011; Dehler et al., 2011; Sangin et al., 2011).
Behavioral awareness	Paying attention to learners’ behavior, including the roles of learners in group coordination, what they have done and how many study tasks they have completed (Janssen et al., 2011).
Social awareness	Paying attention to the operation of the group and know about the interaction among group members, such as learners’ feelings about collaboration among group members, etc (Phielix et al., 2011).

In the FTF (Face-To-Face) , group awareness can be acquired very easily. However, if team members are separated spatially, which means in a CSCL environment, technical support is required if members want to acquire group awareness information[31]. In conclusion, group awareness provides learners with their accompanying learners’ cognitive information, behavioral awareness information, and social awareness information through technical support, inducing the mutual awareness among learners, promoting the interaction among learners and finally improving the effect of collaborative learning in the CSCL environment.

From the perspective of the role and purpose of group awareness information in collaborative learning, firstly, group awareness mainly provides information interaction space for collaborative members. The shared information in the group is about group awareness (Briggs, 2006). The information includes who participated in the collaborative learning, when, where, how, and why to do it, etc. In addition, group awareness can be led by teachers or students. Teachers utilize group awareness to lead collaborative learning better. Learners can know about the teaching of accompanying learners, discover their insufficiency and help to promote practical understanding through group awareness[32]. Although there is no explicit instruction on adjusting their study behavior, learners can adjust by themselves according to group awareness information and actively influence the progress and results of collaborative learning (Bodemer & Dehler, 2011).

As the learning task becomes more complicated, it will be easier to solve study topics through collaboration. At the same time, group awareness information can reduce the effort that group members make to coordinate the action, improve their efficiency and reduce the chance of making mistakes (Gutwin & Greenberg, 2005). Therefore, acquiring group awareness information can reduce learners’ cognitive load to a certain extent[33].

Group awareness can help learners better organize arguments during the period of computer-supported collaborative argumentation. In addition, Sangin and colleagues (2011) clearly express that group awareness can trigger verification and judgment and help with collaborative learning.

Summarizing the propositions of the theories mentioned above, it can be concluded that in a CSCL environment, group awareness can reduce the conflicts among group members and reduce the occurrence of issues of unbalanced participation. Group awareness can help learners adjust by themselves and play the role of an implicit instructor[34]. In addition, group awareness can reduce learners' cognitive load to a certain extent. Furthermore, group awareness can trigger verification and negotiation, which can help learners organize better arguments. Therefore, the premise of conducting the effective computer-supported collaborative argumentation is to allow learners to acquire group awareness information in time.

There are two ways of developing group awareness, one is the results of natural interaction, the other one is acquired utilizing a specific group awareness tool. If there is no support from group awareness tools, group awareness can be developed only in the collaborative process (Schmidt, 2002). When learners have arguments during the collaborative learning, group members know about accompanying the learner's opinions through his argument content and his voice and tone, his emotional status and collaboration satisfaction[35]. It is not hard to find out that it is very common that group awareness information cannot be achieved directly and it needs explaining (Kraut, Fussell, Brennan, & Siegel, 2002).

Therefore, CSCL environment integrated tools or mechanisms can provide group awareness information to learners and promote the collaborative content space and the relationship space. In addition, it can explain group awareness information and help learners know about the information about other group members and the collaboration process. This tool is called a group awareness tool (Buder & Bodemer, 2008)[36].

Group awareness tool has significant meanings to CSCL. Firstly, in a CSCL environment, learners need to collect and interpret a significant amount of information. According to the Cognitive Load Theory (CLT), the collaboration in the CSCL environment produces high-level internal and external cognitive load (Kirschner, Paas, & Kirschner, 2009). Therefore, it should use group awareness tools to collect and explain the necessary information[37]. The method of collecting and presenting necessary information is visualization because visualization can effectively collect and interpret information and reduce the cognitive requirements of individuals (Sweller & Chandler, 1994; Ware, 2005).

Secondly, group awareness tools can strengthen learners' group awareness and improve participation awareness (Gutwin & Greenberg, 2005; Kirschner, Strijbos, Kreijns, & Beers, 2004).

Moreover, because the awareness information is concealed, during the collaborative learning, we can use a group awareness tool, which can present awareness information explicitly. The explicit information can help to instruct learners' behavior and help them reflect (Bodemer & Dehler 2011) and can improve the collaborative efficiency of the group (Schreiber & Engelmann, 2010), as well as promote effective knowledge share (Dimicco et al., 2007)[38].

According to the prior research on group awareness, most representative researches are shown as follows in Table 2.

Table 2 Group Awareness Tools

Tool	Group awareness			Displaying	Functions features
	Cognitive awareness	Behavioral cognitive	Social cognitive		
ShrEdit (Dourish & Bellotti, 1992)	√	√	√	Shared window	Learners' activities can be collected in a shared working space by shared feedback. Then learners can acquire the in-time information of the study of accompanying learners and then adjust their own activities accordingly.
GAW (Kreijns & Kirschner, 2001)	√		√	Timeline diagram	Track the learners' ID, record the activities of each learner and show the time length of learners taken on the platform.
GroupKit (Gutwin & Greenberg, 2002)	√	√		Social relation network diagram	Mark the edition of content from group members and changes of object of study, assist learners to predict the intention of group members.
Augmented Group Awareness Tool (Buder & Bodemer, 2008)			√	Evaluate two-dimentional table	Learners grade the performance of the partner. The grading mainly aims at two indexes : contribution degree and innovation degree. The platform collects and summarizes the assessment results of all members, which will be given feedback to each learner.
SAM (Govaerts et al., 2012)	√	√		line chart, pie chart, tag cloud	The time that visual learners spent on study activities and resource usage help learners reflect and discover potential issues.
PT (Janssen et al., 2011)			√	scatter diagram, social network chart	Pay attention to the contribution from each learner to group cooperation and update learners' performance in real time.
StepUp! (Santos et al., 2013)	√	√	√	bar chart, pie chart	Provide more social interaction information and let learners see others' performance in the community and reflect their own activities.
Radar (Phielix, 2011)			√	radio chart	Show the cognition of learners to members and the assessment of social behavior and help learners reflect study process.
Reflector (Phielix, 2011)			√	text	Let learners reflect the feedback information and think about whether they understand and agree with the feedback results or not, so that learners can more clearly know about their behaviors.
Narcissus (Upton & Kay, 2009)	√		√	tree diagram	Follow the document use among learners and help learners discover the

					contribution the group members have done.
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3. METHODOLOGY

The research methodology in the study follows the Design and Development Research. Design and Development Research is about confirming teaching or non-teaching outcome or tool and leads systematical research methods generated by the newly developed or improved model including the process of design, development, and evaluation based on the empirical foundation (Richey & Klein, 2007)[39].

Design Development Research can be divided into two types - outcome and tool Research (Type 1) and Model Research (Type 2). The model research consists of three processes: model development, model validation, and model use. In this study, the design principles and specific guidelines developed will be generally applicable to computer-supported collaborative argumentation activities based on group awareness tool[40]. Thus, it is suitable to use Model Research (Type 2) of the Design and Development Research.

3.1. Research procedure

The design principles and specific guidelines in the research are the instructional guidelines in different phases of study activities. The research has experienced 5 phases in order to promote the computer-supported collaborative argumentation based on group awareness tool. The specific research procedure and research activities are shown in Table 3[41].

Table 3 Research procedure and research activities

Research procedures	Research activities
Reviewing previous literature	<ul style="list-style-type: none"> • Develop the design principles for group awareness tool (initial design principles) • Develop the function model of group awareness tool in computer-supported collaborative argumentation • Develop specific guidelines of computer-supported collaborative argumentation (initial specific guidelines)
Expert validation	<ul style="list-style-type: none"> • The expert evaluation for initial design principles • The expert evaluation for initial specific guidelines • Analyze expert validation results and modify the design principles for group awareness tool (final design principles) • Analyze expert validation results and modify specific guidelines (modified specific guidelines)
Course application	<ul style="list-style-type: none"> • Design activities of applicable specific guidelines and develop the teaching tools • Apply the specific guidelines in the actual computer-supported collaborative argumentation activity
Investigation on Learners' Responses	<ul style="list-style-type: none"> • Investigate learners' response through questionnaires and interviews
Final specific guidelines	<ul style="list-style-type: none"> • Modify the specific guidelines based on the response from learners (final specific guidelines)

3.2. Participants

In this study, three educational technology experts participated in the expert evaluation. All three experts hold relevant doctoral degrees, and have relevant research experience in the field of educational technology[42].

In addition, the implementation of this course is carried out in the “Basic Knowledge of Computer” course offered by W University in the first semester of 2021. The participants involve 45 students and an instructor from a class of the first year of W University. The 45 students who participated in the course implementation activities all participated in the learners’ response survey. Moreover, five of the learners who agreed to participate in the interview were selected for an interview, who came from five different discussion groups.

3.3. Research tools

3.3.1. Expert validation tool

The expert validation tool was revised according to the study of Nile and Jung (2001), as shown in Table 4 below. A scale was used to measure the responses ranging from 1 indicating “totally disagree” to 4 indicating “agree”[43].

Table 4 Expert Validation Questionnaires for the Specific Guidelines

Item	Content	4	3	2	1
Feasibility	The specific guideline is an applicable and reasonable guideline to promote computer-supported collaborative argumentation based on group awareness tool.				
Explanatory	The specific guideline has interpreted the applicable guideline for promoting computer-supported collaborative argumentation based on group awareness tool very well.				
Usability	The specific guideline can be effectively applied in order to promote computer-supported collaborative argumentation based on group awareness tool.				
University	The specific guideline is in order to promote computer-supported collaborative argumentation based on group awareness tool and can be broadly used.				
Understanding	The specific guideline is the applicable guideline for promoting computer-supported collaborative argumentation based on group awareness tool and can be understood easily.				

3.3.2. Course application tool

The course application tool consists of three aspects as introduction of activity, collaborative argumentation activity, and group reflection[44]. The activity introduction developed study materials and introduced the significance, good conditions of collaborative argumentation, the concept of group awareness, usage of Moodle platform, and usage of group awareness tool. At the same time, examples of providing collaborative argumentation will be given, so that learners can grasp the argumentation activity well. The discussion summary letter during the collaborative argumentation activities was revised by referring to the study of Lee and Yang (2009). And a record paper of the argumentation process was developed[45].

In addition, the individual assessment paper was developed with reference to “clear statement”, “reasonable reasons”, “specific basis”, “considering opposed opinions”, “applying teaching theories”, “original opinion” (Jonassen & Cho, 2011).

The computer-supported collaborative argumentation activities of this research are carried out on the Moodle platform of W University, which can provide real-time group awareness information for learners. The main functions of the collaborative argumentation activities conducted on the Moodle platform of W University are summarized in the following table 5.

Table 5 The Main Functions of Moodle Platform of W University Applied in Computer-supported Collaborative Argumentation Based on Group Awareness Tool

	Description
Chatting Room	Learners can discuss online in the chatting room of the current group
	Check the cognitive awareness information provided by the group awareness tool
	Check the behavior awareness information provided by the group awareness tool
	Check the social awareness information provided by the group awareness tool
Teacher interface	The teacher can check the discussion of all discussion groups

3.3.3. Learners’ response tool

In order to confirm the response of learners to supporting methods applicable to computer-supported collaborative argumentation study activity, the pre-test questionnaire and post-test questionnaire are respectively composed of 14 questions and 37 questions.

The pre-test questionnaire, it consists of 14 questions about the study attitude and sense of self-efficacy to collaborative argumentation activity and group awareness tool. The self-efficacy questionnaire about computer-supported collaborative argumentation activity and group awareness tool were selected and modified in the academic self-efficacy questions from the Motivated Strategies for Learning Questionnaire (MSLQ). The questionnaire about study attitude was revised and developed according to the questions about learning attitude in the Learning and Study Strategies Inventory (LASSI). A scale was used to measure the responses ranging from 1 indicating “totally agree” to 5 indicating “totally disagree”[46].

Based on the questionnaire on learners’ study attitude and sense of self-efficacy to collaborative argumentation activity and group awareness tool, who use the post-test questionnaire during the period of pre-test questionnaire, 23 questions on satisfaction related to supporting methods and overall satisfaction with collaborative argumentation activity have been added extra. Shin (2003) defines the satisfaction degree as follows: for one’s learning experience, the degree of positive relevance that learners felt[47]. Therefore, this study defines satisfaction degree as the learner’s positive or negative cognition between the computer-supported collaborative argumentation based on group awareness tool and learning experience.

3.3.4. Course Development

Specific course content is shown as follows. Firstly, before the application course, the learners, who agree to take part in the study, will be taken as the objects of the study. They completed the questionnaire on their prior experience and sense of self-efficacy of collaborative learning as well as gender, grade, and major. After conducting the pre-test questionnaire investigation, the researcher introduced to the learners the significance of computer-supported collaborative argumentation, conditions of good collaborative argumentation, the concept of group awareness, Moodle platform, and usage of group awareness tool, as well as provided them with sufficient prior training opportunities[48].

In the study, computer-supported collaborative argumentation activities took around 110 minutes every week according to the procedure mentioned in Figure 1, and computer-supported collaborative argumentation activities were implemented for two weeks. The question used in the study selected the non-structure question does not have right answers, for collaborative argumentation is the effective method of the actual non-structure question, which have no right answers (Jonassen & Cho, 2011)[49]. Therefore, the study has selected the argumentation question of “What is the influence of Artificial Intelligence on school education”, which is given to learners.

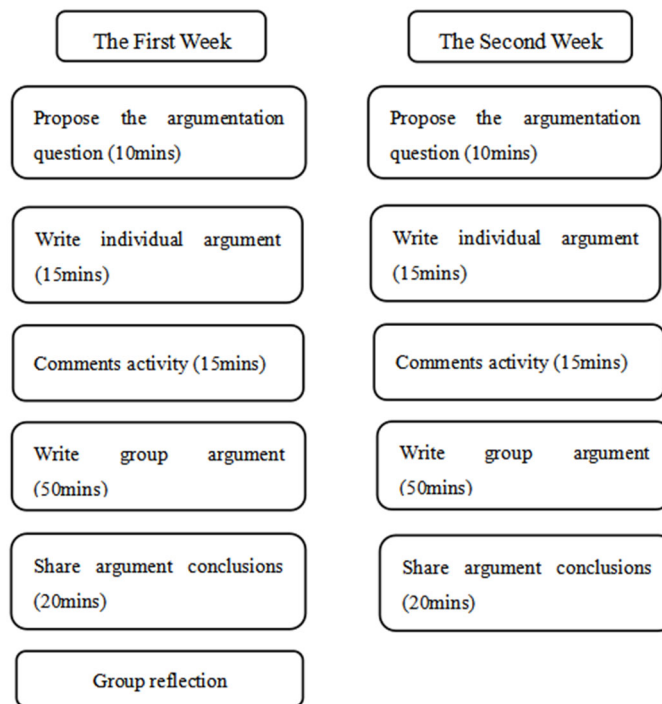


Figure 1 Computer-supported Collaborative Argumentation Procedure

3.3.5. Learners' Response

In order to investigate learners' responses, the researcher conducted the course design at first[50]. Firstly, the researcher explained to the teacher the purpose of the study. The teacher confirmed the purpose of teaching, learners' characters, teaching plans, teaching mode, and evaluation methods. After the researcher and teacher negotiated for the specific topics and activities, the collaborative argumentation activity applicable to the supporting methods lasted for 2 weeks. The researcher observed learners' study activities within two weeks. In addition, when the argumentation activity ended in the second week, the researcher conducted the subsequent investigation through online questionnaire investigation. And within a week of the end of the collaborative argumentation activity, the learners' response to the specific guidelines was investigated through interviews, a total of five learners who agreed to participate in the interview were involved in in-depth interviews.

Questionnaire responses were analyzed to confirm the changing trend based on average values. In addition, the responses were analyzed to calculate the score gap between the pre-test questionnaire and post-test questionnaire through t-verification by SPSS. The results of the interview are analyzed according to Creswell's (2012) material analysis procedure: 1) material exploration and coding. 2) narration and topics acquired. 3) results and report acquired.

4. RESULTS

4.1. Expert Validation Result of Design Principles for Group Awareness Tool

In order to determine the validation of the overall and individual design principles for group awareness tool obtained through previous literature, email exchanges and interviews were conducted with three experts in the field of educational technology. The scale ranges from 1 indicating “totally disagree” to 4 indicating “agree” . The results of the overall evaluation of the design principles for group awareness tool are shown in Table 6. The overall evaluation is based on the average value, standard deviation, content validity index (CVI), and inter-rater agreement (IRA). As seen from Table 4.4, the average value of 2.33 to 4.00, CVI value exceeds the 0.8 proposed by Davis (1992) in addition to the feasibility and universality. Besides, the IRA value is 0.80, indicating that the design principles for group awareness tool need to be modified and improved in terms of feasibility and university.

Table 6 Expert Validation Result for Overall Design Principles

	Expert			M	SD	CVI	IRA
	A	B	C				
Feasibility	3	2	2	2.33	0.47	0.33	0.80
Explanatory	4	4	3	3.67	0.47	1	
Usability	4	3	4	3.67	0.47	1	
University	3	3	2	2.67	0.47	0.67	
Understanding	4	4	4	4	0	1	

Then, the validation for individual design principles for group awareness tool was discussed by experts, and the results are shown in Table 7. The expert validation mainly analyzed 9 items of five design principles, among which the CVI value of 6 items exceeds 0.8, indicating that the individual design principle is reasonable as a whole. However, the CVI value of 3 items is less than 0.8, and the IRA value also exceeds 0.8, which interpreted that only individual items need to be modified.

Table 7 The Expert validation Result for Individual Design Principles

Design principle	Explanation		Expert			M	CVI	IRA
			A	B	C			
1. Provide cognitive, behavioral, and social awareness information at the same time.	cognitive awareness information	Present with the visualized chart on group discussion focus, topic, activation degree, and knowledge novelty.	4	4	4	4	1	0.89
	Behavior awareness information	Present with the pie chart of the behavioral model.	3	4	4	3.67	1	
	Social awareness information	Present with the interactive relations chart the of number of messages left, time of leaving the messages.	3	4	3	3.33	1	
2. Adopt implicit, dynamic, free, and closed display	By the comparative analysis on various ways of presentation of typical events of group awareness tools in the above text, the research will adopt implicit, dynamic, free and closed ways of presentation.		4	4	3	3.67	1	

3. Appropriately monitor study activities	① Monitor knowledge generation and construction.	3	2	3	2.67	0.67
	② Monitor what learners' behaviors are during the collaborative learning.	3	3	3	3.00	1
	③ Monitor the interaction among learners.	2	4	4	3.33	0.67
4. The way of comparing Awareness information among learners should be simple.	Most group awareness tools have the functions of comparing the knowledge and participation degree of learners. If the way of comparison is complicated, it will cause learners burden and wrong understanding to awareness information will hinder study. Therefore, the way of comparison of awareness information must be simple.	3	4	3	3	1
5. During the process of collaborative argumentation, remind learners of checking group awareness tools twice.	During the collaborative study, learners should adjust behaviors decidedly after acquiring the awareness information. In this way, it can make the teamwork towards one direction. Therefore, the study will remind learners of checking group awareness tools twice during the collaborative argumentation.	2	3	3	2.67	0.67

The experts think that an issue related to feasibility and usability is to ensure that each group member will only see the information of themselves and the whole group, but not information of other individual members. Therefore, design principle 3 “Appropriately monitor study activities” can be embodied as appropriately monitor study activities of group members themselves and the whole group.

In addition, the three types of group awareness information in study activities do not need to be divided. They coexist and will all have an impact on study activities. However, according to the different stages of the discussion activity, the group awareness information that learners should focus on is different. For example, the initial stage of the discussion reminds learners to focus on observation of cognitive awareness information; the discussion stage reminds learners to focus on cognitive, behavioral, and social awareness information; the discussion summary and reflection stage remind learners to focus on cognitive, behavioral, and social awareness information. Therefore, in the design principle of group awareness tool, “teacher reminds learners to check group awareness tool twice” can be changed to “teacher reminds learners to check group awareness tool three times in the initial stage of discussion, discussion progress stage, and discussion summary reflection stage”. The expert’s revising suggestions and content are shown in Table 8.

Table 8 The Revising Suggestions for Design Principles by Experts

Category	Suggestions	Revised content
Design Principle 3	Each group member should only see the information of themselves and the whole group, but not information of other individual members.	“Appropriately monitor study activities” can be modified as “appropriately monitor study activities of group members themselves and the whole group” .
Design Principle 5	According to the different stages of the discussion activity, the three types of group awareness information that learners should focus on are different.	“Teacher reminds learners to check group awareness tool twice” can be changed to “Teacher reminds learners to check group awareness tool three times in the initial stage of discussion, discussion progress stage and discussion summary reflection stage” .

4.2. The Final Design Principles for Group Awareness Tool

According to the revising suggestions for initial design principles by experts, the final design principles for group awareness tool are summarized as shown in Table 9.

Table 9 The Final Design Principles for Group Awareness Tool

Design principle	Explanation	
1. Provide cognitive, behavioral, and social awareness information at the same time.	cognitive awareness information	Present with the visualized chart on group discussion focus, topic, activation degree, and knowledge novelty.
	Behavior awareness information	Present with the pie chart of the behavioral model.
	Social awareness information	Present with the interactive relations chart of the number of messages left, time of leaving the messages.
2. Adopt implicit, dynamic, free, and closed display.	By the comparative analysis on various ways of presentation of typical events of group awareness tools in the above text, the research will adopt implicit, dynamic, free, and closed ways of presentation.	
3. Appropriately monitor study activities of group members themselves and the whole group.	① Monitor knowledge generation and construction.	
	② Monitor what learners' behaviors are during the collaborative learning.	
	③ Monitor the interaction among learners.	
4. The way of comparing awareness information among learners should be simple.	Most group awareness tools have the functions of comparing the knowledge and participation degree of learners. If the way of comparison is complicated, it will cause burden on learners and wrong understanding of awareness information will hinder study. Therefore, the way of comparison of awareness information must be simple.	
5. Teacher reminds learners to check group awareness tool three times in the initial stage of discussion, discussion progress stage, and discussion summary reflection stage.	During the collaborative study, learners should adjust behaviors decidedly after acquiring the awareness information. In this way, it can lead the teamwork towards one direction. Therefore, the study will remind learners of checking group awareness tools three times during the collaborative argumentation.	

Based on the revised opinions on the design principles for the group awareness tool given by experts, the design of the group awareness tool was improved, and the revised group awareness tool was applied to the two-week collaborative argumentation activity. From the screen displayed by the learners during the collaborative argumentation activity on the Moodle platform after the first week of the activity, it can be seen that whether the discussion of learners deviates from the topic, the number of discussions on prior knowledge, the main learning behavior of learners, and the interaction with other learners[51].

4.3. Expert Validation Result of Specific Guidelines

In terms of the expert validation of the specific guidelines, the researchers also followed the same procedures through emails and interviews with three educational technology experts. The scale ranges from 1 indicating "totally disagree" to 4 indicating "agree". The expert validation of the

supporting methods was judged from five aspects: feasibility, explanatory, usability, university, and understanding. The results of the overall evaluation of specific guidelines in shown in Table 10.

The expert validation result for individual specific guidelines is 17 items of CVI value exceed 0.8, but 4 items less than 0.8, which interpreted that experts agreed that these initial specific guidelines had some difficulties in usefulness. The IRA value of 0.94 can be seen that the comments of experts are relatively consistent.

The experts agree that this research is a developmental study of group awareness tool based on specific guidelines in computer-supported collaborative argumentation, and some of the specific guidelines are not related to the group awareness tool, so the association with the group awareness tool should be strengthened. And at the same time, some of the specific guidelines should be added or modified, and unnecessary specific guidelines should be deleted. For example, when introducing the activity, students' understanding of the activity is very important, and the difference between the general collaborative argumentation and the computer-supported collaborative argumentation activity based on group awareness tool should be emphasized to facilitate students' better understanding. And the specific guideline 1.3. that provides examples of general collaborative argumentation can be deleted. Besides, "state the steps and rules of collaborative argumentation activities" should be changed to "state the steps and rules of computer-supported collaborative argumentation based on group awareness tool".

And the experts also pointed out that some of the specific guidelines need to be further specified, such as the specific guideline 3.3., it should clarify how the roles among group members will be allocated. Therefore, the role assignments of group members can be designated as leader, organizer, time controller, and summary publisher.

Besides, for learners to better review and summarize the argumentation activity in the reflection phase, "record when they checked the group awareness tool and how to adjust their study activities after checking" should be added. According to the revised design principles for group awareness tool, the specific guideline 4.9. should be revised to "remind the learners to check the group awareness tool three times in the initial stage of discussion, discussion progress stage, summary and reflection stage".

Table 10 Expert Validation Result for Overall Specific Guidelines

	Expert			M	SD	CVI	IRA
	A	B	C				
Feasibility	3	2	3	2.67	0.47	0.67	0.80
Explanatory	3	4	3	3.33	0.47	1	
Usability	3	3	2	2.67	0.47	0.67	
University	3	2	3	2.67	0.00	0.67	
Understanding	4	3	4	3.67	0.47	1	

4.4. Responses of the Learners

4.4.1. Questionnaire results

In order to confirm the responses of learners on specific guidelines, questionnaire surveys were conducted among 45 learners who participated in the computer-supported collaborative argumentation activity, and a total of 45 questionnaire responses were received. Among the four questions set concerning learners' satisfaction with computer-supported collaborative argumentation activity, the average values are between 3.84 and 4.17, it can be seen that the overall satisfaction is higher. In terms of specific guidelines, the lowest average value is 3.71, and the highest average value is 4.24. The following Table 11 is a summary of the learners' responses. As for the

study attitude and self-efficacy of computer-supported collaborative argumentation activity and group awareness tool, questionnaire questions are consisted of study attitude towards computer-supported collaborative argumentation activity (1~3), self-efficacy of computer-supported collaborative argumentation activity (4~6), study attitude towards group awareness tool (7~8) and self-efficacy of group awareness tool (9~ 14). It can be seen that there have been obvious positive changes before and after the computer-supported collaborative argumentation activity. The results of the score gap between the pre-test and post-test through t-verification are shown in Table 12.

Table 11 The Result of the Learners ' Response

Category	Statements	M	SD
Overall satisfaction with collaborative argumentation activity	1. I feel very satisfied with the overall course focusing on collaborative argumentation.	3.84	0.68
	2. I can happily study the content of the course through collaborative argumentation activity.	3.89	0.50
	3. I can better understand the study content in the course through collaborative argumentation activity.	4.13	0.47
	4. I can know about other learners' ideas in the collaborative argumentation activity, which is a very good study experience.	4.17	0.49
Satisfaction with specific guidelines	1. The Introducing PPT on collaborative argumentation activity and group awareness tool provided in advance are useful.	4.20	0.55
	2. Introduce the difference between the general collaborative argumentation and the computer-supported collaborative argumentation activity based on group awareness tool is useful.	4.11	0.57
	3. The procedures and rules stating collaborative argumentation activity based on group awareness tool are useful.	4.23	0.47
	4. The prior knowledge on discussion topics provided is useful.	3.91	0.69
	5. Explaining the argumentation model is useful.	3.77	0.68
	6. Allocating roles before collaborative argumentation activity is useful.	4.19	0.59
	7. Recording the argumentation activity is useful.	4.20	0.52
	8. Learners record when they checked the group awareness tool and how to adjust their study activities after checking are useful.	4.06	0.67
	9. Cognitive, behavioral, and social awareness information simultaneously provided by group awareness tool is useful.	4.03	0.48
	10. The information on group members' contribution level and participation provided by the group awareness tool are useful.	3.83	0.65
	11. The information on learners' understanding level of prior knowledge provided by the group awareness tool is useful.	3.91	0.65
	12. Group discussion progress information provided by the group awareness tool is useful.	4.19	0.50

13. Information of learners' behavioral situations during the discussion provided by the group awareness tool is useful.	4.03	0.56
14. Interaction among group members provided by the group awareness tool is useful.	4.24	0.50
15. Comparative information about knowledge and participation among learners provided by the group awareness tool is useful.	3.74	0.69
16. Teacher reminding learners of checking group awareness tool is useful.	4.06	0.52
17. The procedure when students conduct the individual assessment first and assess with the group members in the group reflection is useful.	3.71	0.56
18. During the group reflection, it is useful to discuss the difficulties coming across in the collaborative argumentation, well-done parts, insufficient parts, and improvement plan.	4.04	0.53
19. The teacher provide feedback not only of argumentation activities, but also difficulties experienced by learners during the collaboration activities are very useful.	3.74	0.55
20. Reviewing the argumentation activity in the first week and revising plans are useful.	4.11	0.46

Table 12 The Result of Study Attitude and Sense of Self-efficacy to Computer-supported Collaborative Argumentation Activity and Group Awareness Tool

Category		M	SD	t	p
Study attitude towards computer-supported collaborative argumentation activity	pre-test	3.92	0.62	5.14	<0.01
	post-test	4.25	0.74		
Self-efficacy of computer-supported collaborative argumentation activity	pre-test	4.06	0.59	4.09	<0.01
	post-test	4.28	0.63		
Study attitude towards group awareness tool	pre-test	3.81	0.73	3.44	<0.01
	post-test	4.13	0.83		
Self-efficacy of group awareness tool	pre-test	3.65	0.64	3.82	<0.01
	post-test	4.10	0.76		

4.4.2. Interview results

Among the learners who participated in the computer-supported collaborative argumentation activity, five of whom participated in the interview. And the five learners came from five different discussion groups. They all stated that they had participated in online collaborative argumentation activities before, but this is their first time to participate in computer-supported collaborative argumentation activities based on group awareness tool. The content of the interview involved four aspects: overall satisfaction of computer-supported collaborative argumentation based on group awareness, satisfaction with group awareness tool, satisfaction with specific guidelines for computer-supported collaborative argumentation based on group awareness tool, and improvement plans. In their opinions,

they were all highly satisfied with the computer-supported collaborative argumentation activity overall.

4.5. The Final Specific Guidelines

According to the results of expert validation and learners' response survey, the specific guidelines were finally derived as the following Table 13.

Table 13 The Final Specific Guidelines

Phase	Segmented activities	Specific guidelines	Tool
Activity introduction	Collaborative argumentation activity introduction	Introduce the significance of collaborative argumentation activity, goals, good conditions of collaborative argumentation, and the importance of group awareness tools in the CSCL environment.	Introducing PPT & Introduction video
		1.2. Introduce the usage on Moodle platform, the usage of group awareness tools, and try to use group awareness tool.	
	Formulate the rules of collaborative argumentation activities	1.3. Introduce the difference between general collaborative argumentation and computer-supported collaborative argumentation activity based on group awareness tool.	
		2.1. State the steps and rules of computer-supported collaborative argumentation based on group awareness tool, to better understand the activity.	
Collaborative argumentation activity	Prior preparation of activity	3. 1. Put forward unstructured discussion topics without standard answers and provide the group's mastery of prior knowledge related to the discussion topic to promote effective collaborative argumentation. (Provide the group's mastery of prior knowledge)	Introducing PPT
		3.2. Before the collaborative argumentation activity, allocate roles as leader, organizer, time controller, and summary publisher among group members.	
		4.1. Structure the argumentation process and record, with the premise of not lowering active interaction among learners. (Assign a group member to do the record work)	Record paper of argumentation process
	Collaborative argumentation activity	4.2. Learners record when they checked the group awareness tool and how to adjust their study activities after checking. (Assign a group member to do the record work)	Record paper of argumentation process

		4.3. Provide learners' cognitive, behavioral, and social awareness information at the same time.	Group awareness tool
		4.4. Provide the contribution level and participation information of group members	Group awareness tool
		4.5. Provide learners' understanding level of prior knowledge	Group awareness tool
		4.6. Provide information about the progress of group discussion	Group awareness tool
		4.7. Provide learners' information of which behavior they are in.	Group awareness tool
		4.8. Provide information about the interaction among group members.	Group awareness tool
		4.9. Provide comparative information of knowledge and participation among learners.	Group awareness tool
		4.10. Teacher reminds learners to check group awareness tool three times in the initial stage of discussion, discussion progress stage, and discussion summary reflection stage.	
	Conclusion publication	5. 1. Publish the argumentation conclusion of the group in the whole class.	
Group reflection and plan revision	Group reflection	6.1. For the process and results of the argumentation activity, first conduct the individual assessment and then conduct group assessment.	Individual assessment paper and group assessment paper
		6.2. During the group reflection, discuss the difficulties experiencing during the collaborative argumentation, well-done parts, insufficient parts, and improvement plan.	
	Feedback is given by the teacher	7. 1. The teacher not only need to give feedback to the argumentation activity, but also give feedback about the same difficulties coming across during the argumentation activity.	
Plan revision	Plan revision	8. 1. Review the argumentation activities in the last week and revise the plan of argumentation activities for the next week.	

5. DISCUSSION AND CONCLUSION

5.1. Discussion

This study aims to promote computer-supported collaborative argumentation based on group awareness tool through the design principles and specific guidelines developed. This study is learner-centered, focusing on exploring the learning process. In addition, in order to improve the quality of computer-supported collaborative argumentation in the second week, this study focuses on learners'

self-reflection, group reflection, and feedback given by the teacher to assess the process of collaborative argumentation activities.

According to the survey of learners' responses, it can be seen that the developed design principles and specific guidelines have a positive impact on learners' learning attitude, self-efficacy and knowledge construction.

First of all, although this study is still insufficient in scientifically demonstrating its effectiveness, it can be verified in the content of the learners' response survey. Because this study is learner-centered, the participation of learners is essential. It can be seen from the results of the learners' response that the learner has changed from a skeptical attitude to a positive attitude towards computer-supported collaborative argumentation activities based on group awareness tool. The research of Bodemer & Dehler (2011) also confirmed that in collaborative learning, group awareness information could have a positive impact on learning progress and results. This study can prove that the actual carrying out of computer-supported collaborative argumentation activities has instructional significance, because the computer-supported collaborative argumentation can deeply learn knowledge related to the discussion topics and better understand the course's content.

Furthermore, the point of most learners is that they can fully express their position and listen to the opinions of other learners through computer-supported collaborative argumentation activities. This study aims to develop design principles and specific guidelines for computer-supported collaborative argumentation activities based on group awareness tool. Therefore, the learners' satisfaction with group awareness tool is also an essential part of the learners' response survey. Through questionnaires and interviews, learners indicated that group awareness tool had played a positive role in computer-supported collaborative argumentation activity. For example, learners have affirmed that the cognitive, behavioral, and social awareness information provided by group awareness tool can fully grasp the learning status of accompanying learners and the current group and adjust learning behavior in time. The feedback of discussion progress can enhance the sense of self-efficacy and significantly affect learners to maintain learning motivation continuously. In addition, the interactive information between group members provided by the group awareness tool can promote the team's collaboration relationship closer. And it can help group members discuss collaboration strategies, evaluate and reflect on their collaborative methods. This is consistent with the results of Phielix, Prins, & Kirschner (2010).

Finally, computer-supported collaborative argumentation based on group awareness tool can promote collaborative knowledge construction. Collaborative knowledge construction is a learning process that encourages mutual assistance and mutual encouragement between learners and the collaborative problem-solving of group dynamics and group performance. In this study, computer-supported collaborative argumentation based on group awareness tool can change the situation that learners dare not question the different views put forward by others. It can be seen from the survey of learners' responses that some learners have apparent changes in their study attitude and self-efficacy before and after participating in collaborative argumentation activity based on group awareness tool. In particular, some learners do not like to refute others' opinions. The learners indicated that this situation had been changed to a certain extent in this activity, and they began to question and deny different views. Sangin and colleagues (2011) also indicated that group awareness could trigger verification and judgment and help with collaborative learning. It is worth mentioning that computer-supported collaborative argumentation is the process of constantly proposing opinions, explaining opinions, refuting and verifying different ideas, evaluating and judging the accepted new ideas, and finally proposing the best solution. And the construction of collaborative knowledge is formed to raise objections and verify different views (Clark, 2013). Therefore, this process can strengthen the depth of interaction between learners and promote collaborative knowledge construction.

5.2. Conclusion and Suggestions

This study aims to verify the teaching value of computer-supported collaborative argumentation based on group awareness tool, and develop design principles and specific guidelines. Compared with the general computer-supported collaborative argumentation activities, this study provides learners with cognitive, behavioral, and social awareness information in the process of argumentation through the support of group awareness tool to adjust their learning activities in time and improve the interaction between learners. Firstly, the initial design principle of group awareness tool and initial specific guidelines were developed by reviewing the previous literature. Then, expert validation was conducted for the initial design principle of group awareness tool and initial specific guidelines by three educational technology experts. The initial design principle and initial specific guidelines were revised and improved based on the revised opinions proposed by experts. After that, the modified specific guidelines were applied to the two-week teaching activities, and the teacher and researchers observed the argumentation activities. After the activities, the learners' response survey was conducted on the learners who participated in the argumentation activities. The learners were generally satisfied with the specific guidelines but also put forward suggestions for improvement. Finally, considering the disadvantage and improvement plans proposed by the learners, the final specific guidelines were developed.

Firstly, this research aims to confirm the teaching and learning significance of computer-supported collaborative argumentation activity and provide design principles and specific guidelines of great importance. This study organized learners participate in a two-week computer-supported collaborative argumentation activity, which can deeply explore the difficulties encountered in the process of collaborative argumentation. Through individual assessment, group reflection, and feedback is given by the teacher, practical and effective solutions were developed.

Furthermore, in order to address the lack of information of accompanying learners in the CSCL learning process, the group awareness tool in this research deeply explores the online collaborative learning process. It deeply analyzes the behavior pattern and interaction of learners in collaborative learning to provide learners with real-time dynamic group awareness information during learning activities. Therefore, the developed design principles and specific guidelines for group awareness tool in this research can find the way out of difficulty encountered by learners in collaborative argumentation activities to a certain extent, promote the interaction between learners, and improve the efficiency of collaborative learning. Jonassen & Kwon (2001) also confirmed that the interaction between learners is one of the critical factors affecting collaborative learning. In future computer-supported collaborative argumentation activities, this study's design principles and specific guidelines can be used as reference.

Finally, while carrying out computer-supported collaborative argumentation, this study also explored the role of group awareness tool in computer-supported collaborative argumentation. For example, how learners adjust their learning based on the awareness information provided by group awareness tool, what disadvantages of group awareness tool are, and what impact it has on learners' psychology. The value of group awareness tool in CSCL should be the realization of interactive quality in a non-face-to-face environment. The application of group awareness tool in the CSCL environment is also to test whether group awareness tool will produce better collaborative learning in terms of process and results. Therefore, this study also has particular reference significance for the future research of group awareness tools in CSCL.

The limitations of this study and suggestions for follow-up research are as follows. The first limitation is related to the composition of the group. In computer-supported collaborative argumentation activities based on group awareness tool, the teacher should allocate groups scientifically and reasonably according to the ratio of male to female, academic level, and personality characteristics, and make adjustments when necessary. For example, more extroverted students will dominate the discussion in group discussions, while introverted students will be excluded. For this reason, the

teacher is required to allocate appropriate roles according to the characteristics of learners to facilitate the complementary advantages of learners and make the learning resources of each group relatively balanced. As for the role assignment before the discussion can also be based on the characteristics of each learner in the group, so that the learners can clarify the tasks and give full play to their advantages.

Secondly, this study has only been carried out on one course for two weeks, and only 45 students in one class participated in the actual teaching activities. And the study is aimed at first-year university learners. These can influence the universality and promotion value of research conclusions. Therefore, it is necessary to further explore and deepen relevant research in the future to obtain more generalizable data.

Moreover, in the collaborative argumentation activities based on group awareness tool, visual feedback to learners' cognitive, behavioral, and social awareness information may have a negative impact on collaborative learning. Although according to the recommendations of expert validation, each group member can only obtain information feedback from himself and the current group, which somehow reduces the psychological burden on learners, but for learners who do not perform well, it may also increase learners' psychological pressure and even cause learner's rebellious psychology. Therefore, the information feedback in the group should not increase the psychological burden on learners. According to Buder (2011), the main task of group awareness tool is to promote collaboration, not to monitor learners. And the group awareness information may infringe on learners' privacy and disturb their learning.

Finally, because the current research on group awareness tool is still in its infancy, there is no research to confirm which group awareness tool can best match learners' characteristics and improve learning outcomes. Therefore, these aspects need to be explored in future research urgently: what is the way of group awareness information generation, how to make learners combine the group awareness information with their learning behavior, and finally make decisions according to the group awareness information, whether the learners have made correct decisions on the adjustment of learning behavior, and what is the effect of the adjustment, and how to balance the primary task (collaboration) and the secondary task (monitoring) in the design of group awareness tool.

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