Analysis of peer-scaffolding patterns in four phases of problem-solving in web-based instruction

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Abstract

Various peer-scaffoldings in problem-solving have been studied as effective learning strategies in web-based instruction and on-line discussion. The web-based environment provides a medium for sharing knowledge and resources, which help learners engage in problem-solving and interactive learning. Learners, however, easily feel isolated in web-based environments because of the tremendous amount of resources and visual information that are easily available. In this regard, it is important to seriously consider peer-scaffolding strategies as effective problem-solving strategies.

The purpose of the present study is to find patterns of peer-scaffolding that constitute effective problem-solving strategies in web-based instruction. Six participants registered in 'the major leader training program' at the National Academy Educational Administrators voluntarily participated in this experiment as part of their coursework. All participants provided their scaffoldings in on-line casual discussions. To collect data from peer group problem-solving interactions in collaborative activities among the six participations, their discourse's content was analyzed to investigate patterns of peer-scaffolding.

The results of this study were as follows: First, the results showed statistically non-significant differences in peer-scaffoldings among three dimensions: it showed the highest proportion of peer-scaffoldings in the

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content dimension, followed by the affection dimension, and finally the strategy dimension. Second, comparing the eight types of scaffolding, the 'offering praise' scaffolding was related to the most important scaffoldings for making peers cooperate with each other while they solve problems. Third, considering patterns of peer-scaffolding in the strategy dimension, the 'maintaining direction' scaffolding represents a higher proportion of the understanding phase than the 'assigning role-taking' scaffolding. Fourth, considering patterns of peer-scaffolding in the content dimension, the 'offering cue' scaffolding represents a higher proportion of the solving phase than the other three peer-scaffoldings. Finally, considering patterns of peer-scaffolding in the affection dimension, the 'inviting participation' scaffolding represents a higher proportion of the understanding phase than the 'offering praise' scaffolding. After reviewing phases, the 'offering praise' scaffolding represented a higher proportion than the 'inviting participation" scaffolding.

Key words: peer-scaffolding, problem-solving phases, web-based instruction

Ⅰ. Introduction

Problem-solving is regarded as one of the most important competency in everyday life and many professional contexts. Thus, in recent years, there has been an increased emphasis on improving students' problem-solving abilities (Phye, 2001). One of the most effective approaches for students to enhance their problem-solving abilities is using web-based environments that allow them to provide peer-scaffoldings to solve a given set of problems. With the advent of the internet, the web has become a prevailing, interactive, and instructional media for distance learning and teaching. The web provides learners with rich resources, information, and dynamic interaction to solve problems without time and space limitations. In other words, web-based environments allow learners to develop their problem-solving abilities, build knowledge, and interact with peers through a web-based learning system (Chou, & Tsai, 2002; Lee, 2004). On the web, students may liberally join discussions to get information related to problem-solving, or provide peer with support.

It is difficult for learners to solve problems successfully without an instructor's or peer's support in a web-based environment. This is because some obstacles, such as the learner's feeling of isolation and communication still remain (Galusha, 1997; Riveran, & Rice, 2002; Sharma & Hannafin, 2007). To overcome these obstacles, scaffolding may play an important role, as experts provide support in these environments and are involved in giving appropriate help. Scaffolding can be defined as expert support for a novice's learning. Shutt (2003) emphasizes that scaffolding encourages and guides learners in order to overcome a learner's feeling of isolation while solving problems, and so that the learner can solve a problem effectively. In this sense, scaffolding is essential to developing a learner's problem-solving abilities under web-based instruction.

When learners need others' help, instructors and more skillful peers can take the role of a scaffolder. To be an expert scaffolder, instructors or peers need to monitor the learners' problem-solving process and provide the appropriate scaffoldings. While learners solve the problems, however, it is not easy for instructors or peers to offer the appropriate scaffoldings to every learner. The reason for this difficulty is that instructors and peers can't interact for sustained periods of time with each individual learner. One way to overcome this difficulty is to have learners work in groups. In other words, one effective approach for learners to increase their problem-solving abilities is through peer interactions during collaborative learning. In recent years, it has been shown that collaborative learning supported by technology can enhance peer interactions conducted in groups (Lipponen et al., 2003). Current research suggests that a collaborative learning environment can positively affect performance on problem-solving tasks.

While individual learners solve the problems, peer interaction is one of the most important ways to prompt this problem-solving process. According to Vygotsky (1978), learners should be scaffolded by a “more capable peer” in order to solve a problem or perform a task that is difficult for them to solve on their own. Also, Scardamalia and Bereiter (1996) note that peer-interaction facilitates learners’ in sharing knowledge as well as developing problem-solving skills, and perspectives on the problem. These studies suggest the importance of peer-scaffolding. Werchadlo and Wollman-Bonilla (1999) use the term ‘peer-scaffolding’ in their study of response writing in the first grade. They emphasize that teacher- and peer-scaffolding are both important components of learning. Lee and Choi (2006) also highlight the importance of peer-scaffolding. They explore differences in the frequency and strategy of scaffolding by a teacher group, a mother group, and a peer group. The results showed that 86% of peer-scaffoldings were appropriate for successful problem-solving.

Although several studies have been conducted on the various scaffoldings in problem-solving situations, few studies address peer-scaffoldings. It is therefore important to understand peer-scaffolding patterns for collaborative problem-solving in web-based instruction environments. The purposes of this study are to explore the types of peer-scaffolding that occur during the problem-solving processes in web-based instruction, as well as to identify what patterns of peer-scaffolding for problem-solving strategies are used to effectively solve problems in the four phases of problem-solving.

Ⅱ. Theoretical Background

A. Concepts and types of scaffoldings

Many scholars explain the concepts of scaffolding in slightly different ways. Peden-McApline (2000) defined scaffolding as a support that an expert provides a learner in order to accomplish problem-solving tasks. Problem-solving requires students to fully employ their knowledge by generating solutions to domain-specific problems. Further, scaffolding must be seen as complex collaborative work, such as the problem-solving process (Hogan, & Pressley, 1997; Roehler, & Cantlon, 1997). In this sense, scaffolding can be characterized by the social interactions between learners.

Scaffolding, then, refers to the process by which a teacher or more knowledgeable peer assist a learner, so the learner can solve a problem or accomplish a specific task (Sharma, & Hannafin, 2007). The concept of scaffolding originated in Vygotsky's socio-cultural theory. Vygotsky (1978) described learning that occurs in the zone of proximal development (ZPD) — the space in which a child can do something, such as complete a task or attain a specific goal with an expert's or more capable peer's support. Hanaffin and colleagues (2001) defined scaffolding as the process for supporting learners while they make efforts or perform tasks.

During the last decade, there have been several studies on various scaffolding types, such as explanation, feedback, direction maintenance, demonstration, and modeling (Bull at al, 1999; Roehler, & Caltlon, 1997; Woods, 1976). These scaffolding types have been found effective in fostering problem comprehension, problem-solving, and reflective thinking. According to Bull and colleagues (1999), when learners can not understand new information, share ideas, and find solutions, instructors or peers can provide explanations, resolve questions, and invite learner participation. In addition, many researchers emphasize how scaffolding can be used in various ways, such as providing explanations or cues and inviting student participation (Flick,1996; Hogan & Pressley, 1997; Kim, 1997; Winnips, & McLoughlin, 2000).

B. Four phases of problem-solving

Problem-solving activities induce the construction of knowledge based on successful retrieval of prior knowledge so that learners can use previously acquired knowledge to solve new problems. To help students enhance problem-solving abilities, the problem needs to be considered very carefully, as the problem itself takes a key role in problem-solving learning.

Learners are generally allowed to solve problems that are decontextualized and well-structured. In contrast, problems in everyday and professional contexts are complex and ill-structured. Jonnassen (2000) described how a range of problem-solving learning results from discriminating between well-structured and ill-structured problems. According to his viewpoint, an ill-defined problem must make students improve their problem-solving abilities and make them apply solutions in everyday life. According to many scholars, however, like Gagné (1985) and Smith, & Ragan (1999), students generally go through similar problem-solving processes regardless of a problem's characteristics.

Newell and Simon (1972) explained that the general problem-solver specifies two sets of problem-solving processes: understanding processes and searching process. Gick (1986) synthesized various other problem-solving models and proposed a simplified model of the problem-solving process: constructing a problem representation, searching for solutions, implementing, and monitoring solutions. Noh and colleagues (2001) proposed that the four stages of the problem-solving strategy are understanding, planning, solving, and checking while investigating the influences of an instructional method related to problem-solving. Park and Kwon (1994) studied students' physics problem-solving processes and the patterns involved in such processes. In that study, they used a coding scheme to analyze problem-solving processes. The coding scheme has four categories: understanding the problem, planning, carrying through a plan, and reviewing. According to Voss and Post (1988), problem-solving has five phases: isolating the major factors involved in reasoning the problem, recognizing different perspectives, removing the causes of the problem, developing matching procedures for applying them, and evaluating solutions by scrutinizing and defending them against alternatives. Ge and Land (2003) studied the effects of question prompts and peer interactions in scaffolding learners' problem-solving processes. In their study, they divided problem-solving into four processes: problem representation, developing solutions, making justification for generating or selecting solutions, and monitoring and evaluating the problem space and solutions.

Considering those phases of problem-solving processes that all researchers suggested, the process can be categorized into four phases: understanding, planning, solving, and reviewing (see Table 1).

<Table 1> Four phases of Problem-solving processes

	Understand-ing	Planning	Solving	Reviewing
Newell & Simon (1972)		-understanding processes	-searching processes	
Gick (1986)	-constructing a problem representation	-searching for solutions	-implementing	-monitoring solutions
Voss & Post (1988)	-isolating the major factors -reasoning the problem -recognizing different perspectives -removing the causes of the problem	-developing and matching procedures for applying them		-evaluating his or her solution
Park and Kwon (1994)	-understanding problem	-planning	-carrying through a plan	-reviewing
Noh et al. (2001)	-understanding	-planning	-solving	-checking
Ge & Land (2003)	-problem representation	-developing solutions	-making justification for generating or selecting solution	-monitoring and evaluating the problem space and solutions.

In the understanding phase, learners understand the situation in a problem, facts and conditions necessary to solve the problem, and goals that will be achieved by solving the problem. In the planning phase, learners develop a tentative plan. More specifically, learners understand additional knowledge for solving the problem, and conduct various levels of research to gain additional knowledge. In the solving phase, learners apply or carry out problem-solving activities based on their plan that they developed in the planning phase. In the reviewing phase, learners examine the appropriateness of solutions and review relevant knowledge regarding problems, the problem- solving process, and self assessment.

C. Relationships between scaffolding and problem-solving

Scaffolding has been found effective in fostering problem-solving (Scardamalia et al., 1984). Hogan and Pressley (1997) emphasize that scaffoldings are needed for students to build powerful thinking strategies for learner inquiries or solving a problem. Reigosa and Jiménez-Alxizandre (2007) note that scaffoldings can be facilitated through open problem-solving activities in a small-group context. Choi and colleagues (2005) report that, through scaffolded instruction, learners take more responsibility for their own learning and become more independent learners. In other words, learners' responsibility and independence, both necessary for successful problem-solving, can be built up by providing scaffolding. According to Wood et al. (1976), scaffolding includes such elements as: arousing a learner's interest in the task; increasing a learner's activity toward task goals like problem-solving; highlighting the critical features of the task or problem; and, modeling the solution to a task. Scaffolding is definitely necessary for students to solve problems successfully because scaffolding helps learners understand the relationships between what they already know and the new information needed to solve a problem.

Ⅲ. Methods

A. Participants

Six participants were involved in solving the given problems as a group. Solving these problems, they shared peer-scaffoldings collaboratively. All of the participants had worked in middle-, upper-, and higher-positions in different fields of administrative divisions, such as research affairs, student affairs, and academic affairs at the three universities in Seoul, Korea. Half of them had an M.A. or Ph. D. in a relevant major field with a working position. In addition, they had worked for more than 10 years in their professional fields. The age range of the six participations, four males and two females, was 40 to 50.

B. Problems as learning task

Participants worked collaboratively in a group and were required to solve problems in a learning task. Problems in the learning task were: (1) to identify topics that will be helpful for solving problems that they may come across in their working field, (2) to search for data and information that is related to problem solving, and (3) to delineate the results of the problem-solving process in an approximately 50-page report.

The activities for solving the given problems in the learning task were as follows: (1) determining what information they already knew, (2) determining what information they still needed, (3) determining how to obtain this information for the problem-solving purposes, (4) determining what information was relevant, (5) applying this new information to solve the problems as a learning task, and (6) evaluating and reflecting on the problem-solving process.

C. Course setting

This course consisted of 15-weeks of a 'major leader training program', in the spring semester of 2008. The instructional goals were to enhance participants' problem-solving abilities and leadership. For these purposes, the problems as a learning task were provided to participants. They were instructed to collaboratively solve the problems with their peers.

This study was conducted in a web-based environment. The participants had to discuss, in an online community, at least 15 hours over the 15 week period in order to solve the problems as a learning task. The tutor explained to the participants that they had to complete the problems in the learning task and actively participate in online-discussions over the course of the semester.

The tutor encouraged participants to provide peer-scaffolding during the problem-solving processes. The tutor emphasized that the elapsed hours of discussion in the on-line environment were important, and that discussion hours could be counted toward scores as well.

D. Procedures of research and data analysis

Data from collaborative on-line discussions were collected from the website for the peer-scaffolding analysis. The website was run in a cyber teaching-learning class. There were two steps in analyzing the data, as will be discussed below.

1. Four phases of problem-solving for analyzing the data

The four phases of problem-solving as shown in Table 1 are understanding, planning, solving, and reviewing. Problem-solving activities in each phase are presented in Table 2. Data were classified into the four phases of problem-solving accordingly.

<Table 2> Four phases of problem-solving and problem-solving activities in each phase

Four phases of Problem-solving	Problem-solving activities
Understanding	-find the given information and goal -confirm the topic to write the report
Planning	-identify additional knowledge to solve the problems -select and organize the contents -discover strategies to write the report
Solving	-collect the information to write the report -write the report collaboratively
Reviewing	-check the solving processes -review the things to learn -reflect on the appropriateness of solutions

2. Coding scheme to analyze peer-scaffolding according to the four phases of problem-solving

In order to analyze the patterns of peer-scaffolding during the collaborative problem-solving activities, a coding scheme for analyzing peer-scaffoldings was developed and elaborated. At first, the three dimensions for analyzing peer-scaffoldings consisted of a strategy dimension, content dimension, and affection dimension. Peer-scaffoldings in the strategy dimension are the ‘maintaining direction’ scaffolding and the ‘assigning role-taking’ scaffolding, which are highly related to ‘how to solve a problem.’ Peer-scaffoldings in the content dimension are the ‘offering cue,’ ‘offering opinion,’ ‘offering explanation,’ and ‘offering feedback’ scaffoldings, which are highly related to ‘what are the necessary contents to solve problems.’ Peer-scaffoldings in the affection dimension are the ‘offering praise’ scaffolding and the ‘inviting participation’ scaffolding, which are highly related to ‘how to enhance the satisfaction and active participation.’ In short, the coding scheme for analyzing peer-scaffoldings is concretely explained in Table 3, which illustrates the dimensions of peer-scaffolding, the types of peer-scaffolding, definitions of peer-scaffolding, and peer-scaffolding examples.

To verify the coding scheme, the tool that Jang (2005) applied in her study was revised and applied in the present study. Using this tool, the coding scheme for analyzing the peer-scaffoldings in Table 3 were validated by experts (1 professor and 3 doctoral candidates) in the instructional psychology field. These experts verified the coding scheme by using a 5-point Likert scale (5=Fully verified, 1=no verified) to rate explicability, usability, validity, comprehensibility, and generality with respect to dimensions of peer-scaffolding, types of peer-scaffolding, definitions of peer-scaffolding, and examples of peer-scaffolding. The results of experts’ verification were shown the average rate of 3.92 out of 5.0. This result confirms that the coding scheme for analyzing peer-scaffoldings is both reliable and valid.

<Table 3 > Coding scheme for analyzing the peer-scaffoldings

Dimension of peer-scaffolding	Types of peer-scaffolding	Definition of peer-scaffolding	Examples
Strategy dimension	maintaining direction	Statements about maintaining joint attention on a goal by requesting clarification.	For completing this task, why don't we consider not only public control universities, but also private control universities as the best case?
	assigning role-taking	Statement need to do to solve problem or task	For gathering meaningful information or materials, we need to assign roles. I'd like to suggest that Mr.000 search on this part because Mr.000 is an expert on this.
Content dimension	offering cue	Statements related to thing sat a problem area, to focus on completing the tasks.	When I was a graduate student in Japan, I carried out a survey similar to this study. That survey may be helpful for our task. So I attached the survey report to refer to our work.
	offering opinion	Statements describing one's thoughts, such as alternative plans to facilitate problem-solving, or tactics to discover a solution.	According to my opinion on administrative services to faculty and students in universities, the professionalism of the staff is a critical factor, I think.

Dimension of peer-scaffolding	Types of peer-scaffolding	Definition of peer-scaffolding	Examples
	offering explanation	Statements adjusted to fit the learner's rising understanding about what is being learned, why and when it is used, and how it is used.	I think it would be better to understand ERIC, which is explained in the blue ocean strategies. ERIC stands for Eliminate, Reduce, Increase, and Create. Eliminate means that consumers are….
	offering feedback	Statements of evaluation of peers' work and pointing out the distinction between the learner's performance and the ideal.	After reading the current survey, we need to add content related to staff promotion to what we're about to write.
Affection dimension	offering praise	Statements that are about encouragement or inspiring peers to further effort, and comments on peers' good work.	Mrs. Jang! ERIC is really important content for completing the task. You provided such appropriate contents to solve this problem. Thank you!!
	Inviting participa-tion	Statements that asked learners to join in problem-solving activities.	Mrs. Jang, I want to get your opinion. Please read the contents of the attached file and give me your opinion or feedback.

Two coders independently analyzed peer-scaffolding messages using the coding scheme validated by our experts. The inter-rater reliability between the two coders was calculated for

25% of the data. The inter-coder reliability (agreement) in each analysis was 73%.

Ⅵ. Results and Discussion

A. The number of peer-scaffolding messages, and proportions according to problem-solving phases

According to our coding scheme, we analyzed all the messages that were discussed among peers in the online community. The total number of messages from learners was 77 postings on the bulletin board. The number of initiating messages was 36, and the number of reply messages was 41. Most messages consisted of approximately 10-20 sentences. In the content analysis, the unit of analysis was the semantic unit. Each message segment was analyzed in light of the eight scaffolding coding scheme categories (See Table 4).

<Table 4> The numbers of peer-scaffolding messages and proportions by problem-solving phases

Dimension	Scaffolding types \ Problem-solving phases	Under-standing phase	Planning phase	Solving phase	Review-ing phase	Total(%)
strategy	maintaining direction	6	1	6	1	**14 (8)**
	assigning role-taking	0	3	8	5	**16 (9)**
	sub total	**6**	**4**	**14**	**6**	30 (18)
content	offering cue	4	3	21	0	**28 (16)**
	offering o pinion	7	0	9	0	**16 (9)**
	offering explanation	8	1	8	6	**23 (14)**
	offering feedback	8	0	1	2	**11 (6)**
	sub total	**27**	**4**	**39**	**8**	78 (46)
affec-tion	Offering praise	5	2	15	13	**35 (20)**
	Inviting participation	9	3	13	2	**27 (16)**
	sub total	**14**	**5**	**28**	**15**	62 (36)
Total(%)		47(28)	13(7)	81(48)	29(17)	170(100)

With respect to the problem-solving phases, the number of peer-scaffoldings was 47 (28%) in the understanding phase, 13 (7%) in the planning phase, 81 (48%) in the solving phase, and 29 (17%) in the reviewing phase. These results show that the highest number of peer-scaffoldings was in the solving phase while the lowest number of peer-scaffoldings was in planning phase. In addition, in terms of peer-scaffolding dimensions, the number of peer-scaffoldings was 30 (18%) in the strategy dimension, 78 (46%) in the content dimension, and 62 (36%) in the affection dimension, respectively (See Table 4).

B. Patterns of peer-scaffoldings in each dimension of the four phases of problem-solving

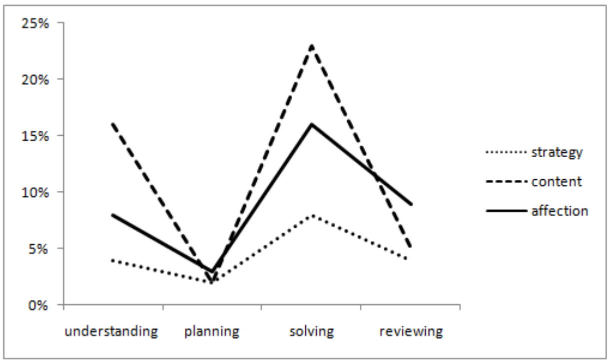
All the messages were analyzed to reveal patterns of peer-scaffolding in each dimension of the four phases of problem -solving. As shown in Figure 1, peer-scaffoldings in the content dimension represented a higher proportion of peer-scaffoldings in the understanding and solving phases than did those in the strategy or affection dimensions. This pattern of peer-scaffoldings in the content dimension indicates that adult participants needed a great deal of knowledge in the understanding and solving phases of the problem-solving process. Further, a chi-square analysis on peer-scaffolding patters according to these dimensions demonstrated that there was a statistically non-significant difference between the strategy, content, and affection dimensions (χ^2= 8.805, p>.05) (see Tables 5, 6).

More specifically, peer-scaffoldings in the strategy dimension were 18% of all peer-scaffoldings across all three dimensions. The strategy dimension includes the 'maintaining direction' scaffolding and the 'assigning role-taking' scaffolding (see Figure 2). The reason for this pattern is that the participants' positions were all in upper-level university administrative organizations, and they had all worked for over 10 years. Thus, the participants tended to keep the strategies that they had in their mind as the most effective and efficient strategies. This means that even though they know various strategies, they use their more familiar strategies when solving a problem without considering the context. In addition, because all of the participants had similar work experiences in the administrative field they could easily have had similar ideas while they made plans to find a solution. There is a thread of connection between this result and German and Defeyter's (2000) results. These authors found that older learners failed to overcome the 'force of habit' when they attempted to generate alternative strategies or solutions during tasks like problem-solving. In other words, adult learners are often used to their own way of problem-solving.

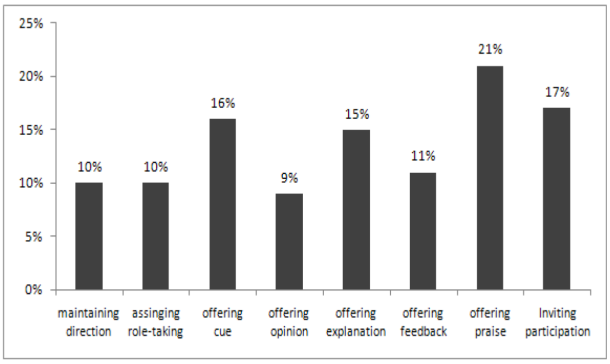
The peer-scaffoldings in the content dimension were 46% of all peer-scaffoldings across all three dimensions, and content dimension includes the four peer-scaffoldings of 'offering cue,' 'offering opinion,' 'offering explanation,' and 'offering feedback' (see Figure 2). This result suggests that participants have sufficient expert knowledge related to problem-solving, especially as participants were sufficiently experienced for a long time in their professional job areas. This result is confirmed by Siegler (1978), who found that older learners recognize the necessity of knowing information about multiple task dimensions, while younger learners do not. As the results of Seigler's research imply, adult learners need peer-scaffolding in the content dimension more than they do in the strategy and affection dimensions in order to find solutions.

The peer-scaffoldings in the affection dimension accounted for 36% of all peer-scaffoldings across all three dimensions, and the affection dimension includes the 'offering praise' and 'inviting participation' scaffoldings. This result shows that participants recognized that peer-scaffoldings in the affection dimension were more important than scaffoldings in the content and strategy dimensions.

Comparing the eight types of scaffoldings, however, we see that the number of messages in the 'offering praise' scaffolding was higher than that of any other type of scaffolding. This implies that adults consider a permissive atmosphere to be an important factor for successfully solving problems (see Figure 2). These findings are supported by Schwarz and Skurnik's (2003) study on the interplay between feeling and thinking. These authors suggest that positive and negative moods and emotions can both help and hinder problem-solving. In this sense, it is worth emphasizing the importance of peer-scaffolding in the affection dimension.



<Figure 1> Patterns of peer-scaffoldings according to the four phases of problem-solving



<Figure 2> Distribution of peer-scaffoldings in all problem-solving processes

<Table 5> Dimension * problem-solving phase Cross-tabulation

			problem-solving phase				Total
			Under-standing	Plann-ing	Solving	Review-ing	
Dimen-sion	Strategy	Count	6	4	14	6	30
		%within dimension	20.0%	13.8%	46.7%	20.0%	100.0%
		% within phase	12.8%	30.8%	17.3%	20.7%	17.6%
		%of total	3.5%	2.4%	8.2%	3.5%	17.6%

			problem-solving phase				Total
			Under-standing	Plann-ing	Solving	Review-ing	
	Content	Count	27	4	39	8	78
		%within dimension	34.6%	5.1%	50.0%	10.3%	100.0%
		% within phase	57.4%	30.8%	48.1%	27.6%	45.9%
		%of total	15.9%	2.4%	22.9%	4.7%	45.9%
	Affec-tion	Count	14	5	28	15	62
		%within dimension	22.6%	8.1%	45.2%	24.2%	100.0%
		% within phase	29.8%	38.5%	34.6%	51.7%	36.5%
		%of total	8.2%	2.9%	16.5%	8.8%	36.5%
Total		Count	47	13	81	29	170
		%within dimension	27.6%	7.6%	47.6%	17.1%	100.0%
		% within phase	100.0%	100.0%	100.0%	100.0%	100.0%
		%of total	27.6%	7.6%	47.6%	17.1%	100.0%

<Table 6> χ^2 test on the patterns of peer-scaffolding according to dimensions

	value	df	Asymp.Sig.(2-sided)
Pearson Chi-Square	8.805[a]	6	.185
Likelihood Ratio	8.795	6	.185
N of Valid Cases	170		

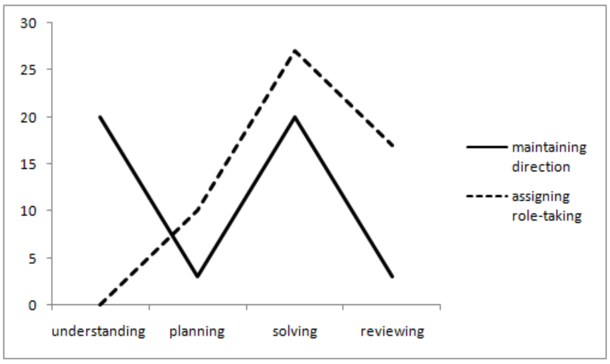
a. Cells (16.7%) have expected counted less than 5. The minimum expected counted is 2.29.

C. Patterns of peer-scaffolding according to each peer-scaffolding dimension

We analyzed patterns of peer-scaffolding according to each peer-scaffolding dimension using our peer-scaffolding coding scheme.

1.Patterns of peer-scaffoldings in the strategy dimension

A chi-square test on patterns of peer-scaffolding by strategy dimension demonstrated that there was a statistically significant difference between the strategy, content, and affection dimensions (χ^2= 9,863, p<.05) (see Tables 7, 8). Despite the statistical significance of these results, we should be careful about accepting the significance, as 9 out of 16 cells had expected counts under five. More specifically, considering the patterns of peer-scaffolding in the strategy dimension (see Figure 3), the 'maintaining direction' scaffolding represents a higher proportion than the 'assigning role-taking' scaffolding in the understanding phase. This result suggests that participants discussed 'what learner should think of completing the task,' and 'what goals and directions are needed to solve the problem.' After understanding problems as a task, the 'assigning role-taking' scaffolding was the highest frequency scaffolding from the planning to the reviewing phase. The reason for this is that, after the understanding the problems, it was crucial for participants to commit to roles for problem-solving and become involved in the problem-solving activities.



<Figure 3> Patterns of peer-scaffoldings in strategy dimension

<Table 7> strategy* problem-solving phase Cross-tabulation

			problem-solving phase				Total
			Under-Standing	Plann-ing	Solving	Review-ing	
strategy	maintain-ing direction	Count	6	1	6	1	14
		%within dimension	42.9%	7.1%	42.9%	7.1%	100.0%
		%within phase	100.0%	25.0%	42.9%	16.7%	46.7%
		% of total	20.0%	3.3%	20.0%	3.3%	46.7%
	assigning role-taking	Count	0	3	8	5	16
		%within dimension	.0%	18.8%	50.0%	31.3%	400.0%
		% within phase	.0%	75.0%	57.1%	83.3%	53.3%
		% of total	.0%	10.0%	26.7%	16.7%	53.3%
Total		Count	6	4	14	6	30
		%within dimension	20.0%	13.3%	46.7%	20.0%	100.0%
		% within phase	100.0%	100.0%	100.0%	100.0%	100.0%
		% of total	20.0%	13.3%	46.7%	20.0%	100.0%

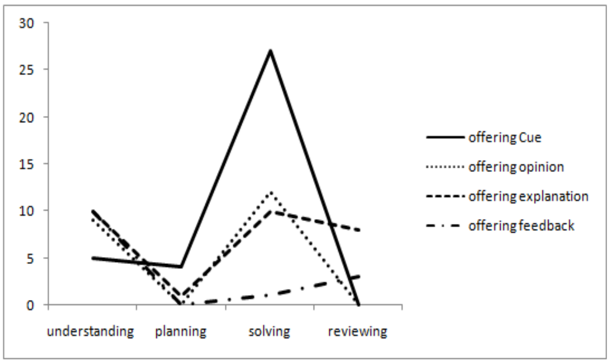
<Table 8> χ^2 test on the patterns of peer-scaffolding in the strategy dimension

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.863[a]	3	.020
Likelihood Ratio	12.429	3	.006
N of Valid Cases	30		

a. 6Cells (75.0%) have expected counted less than 5. The minimum expected counted is 1.87.

2. Patterns of peer-scaffolding in the content dimension

A chi-square test on the patterns of peer-scaffolding in the content dimension showed that there was a statistically significant difference between the strategy, content, and affection dimensions (χ^2 = 30.639, p<.05) (see Table 9,10). Again, despite the statistical significance of this result, we should be careful in accepting this, as 9 of 16 cells had expected counts lower than five. More specifically, the ‘offering cue’ scaffolding represents a higher proportion than do the other peer-scaffoldings in the solving phase, as participants recognized that their peers had high levels of problem-solving abilities and had accumulated prior knowledge (See Figure 4). This finding confirms the results of studies (e.g., Lepper et al., 1990; McArthur et al., 1990) on the utilization of cues in the context of adults' speech acts. This result means that cues provided by adults facilitated learners' active problem-solving.



<Figure 4> Patterns of peer-scaffoldings in the content dimension

<Table 9> content* problem-solving phase Cross-tabulation

			problem-solving phase				Total
			Under-standing	Plann-ing	Solving	Review-ing	
content	offering cue	Count	4	3	21	0	28
		%within dimension	14.3%	10.7%	75.0%	.0%	100.0%
		% within phase	14.8%	75.0%	53.8%	.0%	35.9%
		% of total	5.1%	3.8%	26.9%	.0%	35.9%
	offering explanation	Count	8	1	8	6	23
		%within dimension	34.8%	4.3%	34.8%	26.1%	100.0%
		% within phase	29.6%	25.0%	20.5%	75.0%	29.5%
		% of total	10.3%	1.3%	10.3%	7.7%	29.5%
	offering feedback	Count	8	0	1	2	11
		%within dimension	72.7%	.0%	9.1%	18.2%	100.0%
		% within phase	29.6%	.0%	2.6%	25.0%	14.1%
		% of total	10.3%	.0%	1.3%	2.6%	14.1%
	offering opinion	Count	7	.	9	0	16
		%within dimension	43.8%	.0%	56.3%	.0%	100.0%
		% within phase	25.9%	.0%	23.1%	.0%	20.5%
		% of total	9.0%	.0%	11.5%	.0%	20.5%
Total		Count	27	4	39	8	78
		%within dimension	34.6%	5.1%	50.0%	10.3%	100.0%
		% within phase	100.0%	100.0%	100.0%	100.0%	100.0%
		% of total	34.6%	5.1%	50.0%	10.3%	100.0%

<Table 10> χ^2 test on the patterns of peer-scaffoldings in the content dimension

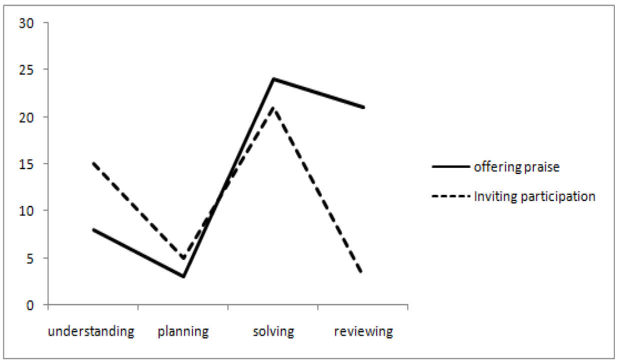
	value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	30.639[a]	9	.000
Likelihood Ratio	35.671	9	.000
N of Valid Cases	78		

a. 9 Cells (56.3%) have expected counted less than 5. The minimum expected counted is .56.

3. Patterns of peer-scaffolding in the affection dimension

A chi-square test on patterns of peer-scaffolding in the affection dimension demonstrated a statistically significant difference between the 'offering praise' scaffolding and the 'inviting participant' scaffolding (χ^2 = 8.664, p< .05) (see Tables 11, 12). More specifically, the 'inviting participation' scaffolding represented a higher proportion than did the 'offering praise' scaffolding in the understanding phase.

The understanding phase is an early part of the problem solving process, and participants are not yet intimate friends each other in this early phase. Accordingly, participants did not actively interact with their peers to solve the problems. So, in the understanding phase, they provided the 'inviting participation' scaffolding more than the 'offering praise' scaffolding. On the other hand, in the later reviewing phase, the 'offering praise' scaffolding represented a higher proportion than did the 'inviting participation' scaffolding (see Figure 5). The reason for this is that when participants reviewed the problem-solving process, they were more likely to offer praise to peers so that they were able to actively engage in problem-solving and complete the task.



<Figure 5> Patterns of peer-scaffolding in the affection dimension

<Table 11> affection* problem-solving phase Cross-tabulation

	problem-solving phase	Total

			problem-solving phase				
			Under-standing	Plann-ing	Solving	Review-ing	Total
Affec-tion	inviting Participa-tion	Count	9	3	13	2	27
		%within dimension	33.3%	11.1%	48.1%	7.4%	100.0%
		% within phase	64.3%	60.0%	46.4%	13.3%	43.5%
		% of total	14.5%	4.8%	21.0%	3.2%	43.5%
	offering Praise	Count	5	2	15	13	35
		%within dimension	14.3%	5.7%	42.9%	37.1%	100.0%
		% within phase	35.7%	40.0%	53.6%	86.7%	56.5%
		% of total	8.1%	3.2%	24.2%	21.0%	56.5%
Total		Count	14	5	28	15	62
		%within dimension	22.6%	8.1%	45.2%	24.2%	100.0%
		% within phase	100.0%	100.0%	100.0%	100.0%	100.0%
		% of total	22.6%	8.1%	45.2%	24.2%	100.0%

<Table 12> χ^2 test on the patterns of peer-scaffolding in the affection dimension

	value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.664[a]	3	.034
Likelihood Ratio	9.482	3	.024
N of Valid Cases	62		

a. 2 Cells (25.0%) have expected counted less than 5. The minimum expected counted is 2.18.

V. Conclusions and Implications

Various peer-scaffoldings are critical elements for effective problem-solving. But little research exists on what patterns and types of peer-scaffolding are practiced during group problem-solving, and what types of peer-scaffolding occur during the four problem-solving phases.

The purposes of this study were to analyze the types of peer-scaffolding messages during on-line problem-solving, and to investigate patterns of peer-scaffolding as effective problem-solving strategies in the four phases of problem-solving.

The major findings of this study on the patterns of peer-scaffolding are as follows:

First, peer-scaffoldings in the strategy dimension accounted for only 18% of all peer-scaffoldings across all three dimensions. According to the chi-square value, this resulted from a statistically significant difference, though we are careful to interpret this result given expected counts under five in the chi-square test. More specifically, considering patterns of peer-scaffolding in the strategy dimension, the 'maintaining direction' scaffolding represented a higher proportion than did the 'assigning role-taking' scaffolding in the understanding phase. These results imply that, because participants have a lot of problem-solving experience, they tend to choose the most effective strategy that they usually apply to solve problems, and apply to the same strategy to solve the problem at hand.

The chi-square analysis was significant, but it should be interpreted with caution since the number of samples was under five. Despite this caution, this result implies that it is important to check the extent of the learners' prior knowledge and adapt the problems' difficulty level accordingly. In this sense, tutors should encourage adult learners to make use of prior knowledge in the problem-solving process. More concretely, considering patterns of peer-scaffolding in the content dimension, the 'offering cue' scaffolding was a higher proportion here than were other peer-scaffoldings in the solving phase. This result implies that, when tutors provide scaffolding to learners, tutors should provide the 'offering cue' scaffolding instead of the 'offering explanation' or the 'offering feedback' scaffoldings in the solving phase. In addition, the 'offering cue' scaffolding should be considered a critical factor in designing problem-solving instruction.

Third, comparing all different types of scaffoldings, the ‘offering praise’ scaffolding is the highest proportion among all types of peer-scaffoldings. More concretely, in the affection dimension, the ‘inviting participation’ scaffolding represented a higher proportion than did other peer-scaffoldings in the understanding phase. On the other hand, in the reviewing phase, the ‘offering praise’ scaffolding represented a higher proportion than the ‘inviting participation' scaffolding. These results imply that, when we design collaborative problem-solving instruction in a web-based environment, we must consider the ‘offering praise’ scaffolding in the affection domain. In addition, tutors should be guided to offer more praise to their adult learners.

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