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Collaboration Scaffolding in Computer-supported Collaborative Learning Environment*

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Supporting individual or group learners through designing effective learning environment has been major concern for instructional technologists. In CSCL environment, the effectiveness of learning depends not only on the design of the learning incidences but also on that of psychological environment because in CSCL the learners encounter virtually a new environment deviate from the ordinary physical world. CSCL is one of the most demanding environment for learners and thus it requires a highly refined learner support mechanisms. The purpose of the research was to devise conceptual tools for supporting learners in CSCL environment. Especially, the researchers tried to develop special kinds of scaffolding that directly support the collaborative practice in the social and psychological dimension of the learner. Body of literature on scaffolding has been reviewed and effective CSCL environments were observed and analyzed. As a result of the study, the research proposes a new type of scaffolding, named as "collaboration scaffolding" as a conceptual tool for supporting learners in CSCL environment. Also the research suggests three subtypes of scaffolds as the most typical collaboration scaffolding; emotional scaffolds, facilitative scaffolds, and exploratory scaffolds.

Keywords : CSCL, collaboration scaffolding, emotional scaffolds, facilitative scaffolds, exploratory scaffolds

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Introduction

Despite of several traditional CSCL (Computer- Supported Collaborative Learning) theories and much positive research on this field, there are many educators and developers who still suffer bitter controversies of what have been discovered and what have been disturbed in the actual CSCL situations. (Stahl, 2003; Kreijns et al., 2002). Too often learners get frustrated before they finally dive into the meaningful interaction that can bring on interactive group learning, shared understanding, and social construction of knowing. Kreijns et al. (2002) mentioned pitfalls that impede achievement of the desired social interaction in CSCL. According to them, we take social interaction in groups for granted and we do not take the social psychological dimension of CSCL into careful consideration. And a recent literature review also criticizes this assumption that social interaction will happen automatically in the CSCL environments (Kreijns et al., in press cited in Kreijns et al., 2002). Wegerif (1998) also advocates careful attention on the social psychological dimension of CSCL, pointing out that "forming a sense of community, where people feel they will be treated sympathetically by their fellows, seems to be a necessary first step for collaborative learning. Without a feeling of community people are on their own, likely to be anxious, defensive and unwilling to take the risks involved in learning" (p. 48).

In CSCL environment there are some typical challenges for learners. First, synchronously or asynchronously learners could easily get lost in CSCL activities because the CSCL environment is open and flexible environment with little guide or help available for them (Crawley, 1999). Second, in many cases learners have no choice to select tasks according to their different aptitudes and interests (Fjuk & Ludvigsen, 2001). In a typical CSCL environment, all learners are expected to solve one common problem. Third, even though many learners are visible in the shared space, it may not be easy to talk to anybody in the space. Learners could feel that they are aliens in a wonderland (Jones, 2005).

There has not been enough amount of research on what kinds of CSCL design features can actually support learners' collaboration and can make their social

interaction really happen. Most CSCL research has focused on effects of CSCL in comparison with individual learning (Kolodner & Guzdial, 1996). Rather than taking a close look at the collaborative learning process itself where many puzzled learners do not dare to ask for help, so much focus has been put on the learning outcome of individual learners (Kim & Kwon, 2006). In order to support collaboration process directly, there should be more research effort on the specific features supporting CSCL process.

The purpose of the research is to devise conceptual tools for supporting learners in CSCL environment. Especially, the researchers try to develop special kinds of scaffolding that directly support the collaborative practice in the social and psychological dimension of the learner. The study proposes a specific scaffolding type, named as "collaboration scaffolding," and to describe its subtypes based on the traditional CSCL theories and literature on scaffolding; emotional scaffolds, facilitative scaffolds, and exploratory scaffolds.

Scaffolding in Learning

The word 'scaffold' or 'scaffolding' originally means "a temporary framework of metal poles and planks used as a platform from which building repairs or construction can be carried out (Yahoo Dictionary)." A construction dictionary adds the meaning of 'beyond reach', defining it as "a temporary structure or platform made of metal framing from which workers can access difficult-to-reach areas (Google Dictionary)". The metaphor has been extended to instructional methods and come to mean "the process by which a teacher or more knowledgeable peer assists a learner, altering the learning task so the learner can solve problems or accomplish tasks that would otherwise be out of reach" (Collins et al., 1989; Wood et al., 1976 cited in Bruce, Reiser & Edelson, 2004). It provides learners with critical helps in critical positions or moments until they get the whole complete structure of understanding.

The term scaffolding was introduced to psychology by Wood, Bruner and Ross (1976) (Bruce, Reiser & Edelson, 2004). Since then, there have been various research efforts on the scaffolding methods and their implementation in classrooms and in recent advanced learning systems. Scaffolding embedded in educational software is suggested by Eliot Soloway and his research group (Soloway, Guzdial & Hay, 1994;. Jackson, Krajcik & Soloway, 2000). Jackson, Krajcik, & Soloway (2000) suggests three types of learning scaffolding. One type, supportive scaffolding, assists the learner in performing a task, such as providing a model of the task or guiding the learning, while a second type, reflective scaffolding, asks questions to prompt the learner to reflect on the task, the degree of success, or ways to generalize from the task to other situations. The third scaffolding technique, which may be implemented in different ways, supports the learner by highlighting or emphasizing important conceptual aspects of the knowledge relevant to accomplishing the task. Hannafin et al. (1999) suggests four types of scaffolding; conceptual, metacognitive, procedural and strategic. Conceptual scaffolds guide students in what to consider; metacognitive scaffolds are about how to think; procedural scaffolds guide students how in to utilize the available features for learning purposes; and strategic scaffolds provide macro-strategy as needed. Tabak(2004) proposed 'distributed scaffolding' focusing on multiple agents of the scaffolds. Brush & Saye (2001) and Jacobson & Archodidou (2000) stressed on the embedded-ness of scaffolding. Dodge (2000) classified scaffolding into three; reception, production and transformation scaffolding, helping learners deal with information, helping learners transform information into new forms, and helping learners create products.

Although this body of literature on scaffolding has addressed how to support individual or group learning, ways to support the collaboration process directly have not been carefully investigated. Kolodner et al. (2003) pointed exactly to the need for special kinds of scaffolds that would prepare members for the collaborative practices of a community of learners rather than an individual.

Collaboration Scaffolding

Collaboration Scaffolding is a system of scaffolds that would directly promote collaboration process. It prepares a community of learners — rather than an individual members — for the collaborative practices (Kolodner et al., 2003). It can initiate, encourage and sustain their social interaction. It focuses more on social psychological dimension of social interaction that has been assumed to happen automatically (Kreijns et al., 2002; Wegerif, 1998). Davis & Miyake (2004) introduced the recent special issue of the Journal of Learning Sciences and raised a critical question to suggest areas left to investigate; "when the goal of the scaffolding is not the development of individual capabilities but rather the development of a culture with particular characteristics, could researchers simply expand what we know as scaffolding now to achieve such goals?"(p. 271). We hope that the concept of collaboration scaffolding would answer a part of this question. The collaboration scaffolding has three subtype scaffolds; *emotional scaffolds, facilitative scaffolds, and exploratory scaffolds*.

Emotional Scaffolds

Emotional scaffolds are one type of collaboration scaffolding that would provide learners with emotional interaction devices such as emotion expression tools, by which help foster positive social climate i.e. social affordances (Gunawardena, 1995; Kreijns et al. 2002; Gaver, 1991). Emotional expressions and emotional interactions among learners can help learners form socially coherent groups or communities.

Learners who may just step into a CSCL environment could feel alone or uncertain (Dede et al., 2004; Dede et al., 2000). They may not have met each other before, and they are connected to one shared alien space by internet network across the globe. An advanced communication technology such as text chat systems cannot guarantee their active engagement. Social interaction will not occur just because the environment

made it possible, and it encompasses all interactivity among learners (Kreijns et al., in press cited in Kreijns et al., 2002).

Kreijns et al. (2002) described those situations where social interaction could be provoked by emotional interaction: "once a member become salient, the social affordances not only invite but also guide another member to initiate a task or non-task related interaction with the salient member"(p.10). For example, if an avatar of a learner expresses her joy with dance, it provokes other learners to ask why she is so happy. The emotional scaffolds function to make those members salient and to initiate conversation. Those kick-off conversations could lead unfamiliar learners to break ice, which is a necessary first step for collaborative learning (Wegerif, 1998).

Examples of emotional scaffolds

River City developed by Harvard Graduate School of Education involves teams of middle school students who are asked to collaboratively solve the health problems of a simulated 19th century city. The avatars of the learners themselves populate the city, along with computer-generated agents, digital objects that can include audio or video clips, and the avatars of instructors. Students are asked to identify problems through observation and inference, form and test hypotheses, and deduce evidence-based conclusions about underlying multi-causes. They can communicate with one another with the group-chat function (Dede et al., 2004).

Video footage transcription of a team of middle school 8th graders in Boston area is shown below with system features. By one click, learners can express their happiness, surprise, angry and so on. Learners can also jump, turn, dance, wave hands, or karate.

With a dancing avatar, the learner starts to be perceived salient, which provokes other learners' reaction. These non task-related casual conversations are working as a gateway to start social interaction amongst learners. Emotional scaffolds scaffold collaboration usually in the initial stage of collaborative process.

Similar function can be easily found in many CMC (Computer Mediated Communication) tools besides educational media. Emoticons and mini-me shown in

Fig. 2 and Fig. 3 can be good examples. Emotions are popular in every IMS (Instant Messaging System), which also can be widely being used in educational settings. It delivers sender's emotion efficiently and effectively such as joy, anger, shyness, sadness and so on. In a text-based communication setting, emoticons certainly promote social interaction and make the atmosphere more sociable.

S1: Anybody here?
S2: <S2 waves hands to S1> Welcome! I am here!
S1: What's happening here?
S2: <S2 dances with joy>
S1: Good dance! Why are you so happy?
S2: I just found the city map! Have you looked at it?
S1: Oh, where can I get the map? With the map, we can plan our navigation strategy!
< S1 kicks karate>

Figure 1. Function keys for emotional expressions and a dancing avatar

Figure 2. Diverse emoticons of MSN, Skype and NateOn

Mini-me's also can be a good example that has emotional scaffold functions. It is like avatars in asynchronous CMC environment. The author of an individual website or a message posting can make display their mini-me's according to their current situations, interests, and emotions. They can also keep changing their mini-me's on their own. Visitors' boards or bulletin boards with mini-me's often have increased postings asking what happened to the author.

Figure 3. Mini-Me's of Cyworld.com

Facilitative Scaffolds

Facilitative scaffolds are one type of collaboration scaffolding that would guide social interactions by piquing both emotional curiosity and cognitive curiosity to conversations among learners. It functions as a moderator, and sometimes it is similar to reflective scaffolding. The difference between reflective scaffolding and this facilitative scaffold is that whereas the former is to prompt questions that make learner reflect the task, the latter does not confine to raising questions, but it arouses learners' attention by not only asking questions, but also by pretending that he/she is curious, ignorant, or shocked, by activating prior or shared knowledge, by highlighting discrepancies or other actions to promote learners' social interactions

and so on. It could be a combination of reflective scaffolding and supportive scaffolding. It could be similar to 'problematizing' which Reiser(2004) described as "drawing learners' attention to issues or tasks they might otherwise choose to ignore, in part because of their natural tendency toward the path of least cognitive resistance"(p. 287).

This type of scaffolds is provided by teachers, tutors, experts or advanced peers. It falls in line with Vygotsky's 'Zone of Proximal Development' (ZPD) (Rogoff, 1990; Reiser, 2004). ZPD says that there is an area that individuals can achieve with the help of more capable peers, adults, or artifacts (Vygotsky, 1978). Cognitive apprenticeship and teleapprenticeships also partly supports this facilitative scaffolding in that both focus on guided practice of more knowledgeable person (Collins et al., 1989; Levin& Waugh, 1998).

What makes facilitative scaffold unique among many other similar scaffolding types is that it draws not only cognitive attention but also emotional attention of the timid learners. What makes facilitative scaffold different from reflective scaffolding and supportive scaffolding is that it targets at a group of learners, not an individual learner. It aims at arousing attention of a group of learners and finally opening their mouths for interaction.

Examples of facilitative scaffolds

In the River City, a special avatar takes the role of facilitating scaffolds even if it looks same as students' avatars. Facilitative scaffolds attract students' attention on important clues; ask questions to assign subtasks to individual students based on each student's expertise or interests; or attempt deliberate mistakes to provoke discussions. Below is an actual discussion among students.

Another example of facilitative scaffolds in CSCL environment could be PBL-protocols (Miao et al., 2000) developed by German National Research Center for Information Technology. PBL-protocols are designed to support problem-based learning in a virtual learning environment. Learners in PBL protocols collaboratively

build a shared hyper-document to represent their shared knowledge. Tutor and students can create different kinds of notes. Only students can define the problem using 'problem' nodes and 'is_a_sub_of' links in order to show how the problem decomposes into sub problems. The result is a network of nodes shown in Figure 4.

S1: I am here in the City Hospital. Oh, I am stuck on the wall.

S2: There is a patients' admission chart on the table.

C: Let's look into the chart and see who the patients are and why they came to this hospital.

S3: Most of them came here because of diarrhea!

C: Anybody know the reason of diarrhea?

S1: I guess bad food…or bad water…maybe.

C: They eat same food? Or same water?

S2: Oh, 4 out of 5 came from the same area! Look at their address on the chart. The Tenement street!

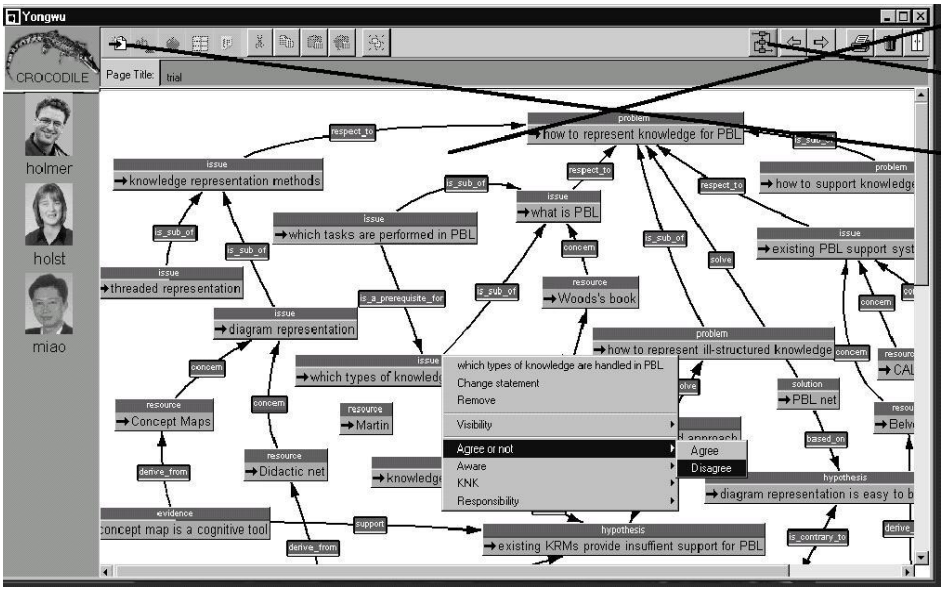

Figure 4. The network of nodes in PBL-protocol

Tutor takes facilitative scaffolds' role. The tutor can create 'source', 'hint' and 'question' nodes, giving indirect help in how to define the problem in the share space. Learners can respond to the tutor using 'answer' nodes, use 'comment' nodes to comment on the contributions of others, and can ask their own questions (Miao et al., 2000). What's important here is that the tutor raises questions and gives hints in the shared space, not in an individual space, which draws shared attention on a certain matter, provokes conversations and guides a group of learners to construct shared representation. This PBL protocol also has embedded facilitative scaffolds as shown in the box asking 'Agree or not' in the Fig. 4, and it also has made 'comment' node to encourage learners to exchange comments on other learners' nodes, and to provoke social interaction among them.

Exploratory Scaffolds

Exploratory scaffolds are one type of collaboration scaffolding that would provide learners with shared exploration opportunities by locating them in contexts where well-designed tasks and diverse clues are given. Those contexts naturally promote social interaction among learners since performing the shared task necessarily requires them shared ground of understanding on the contexts (Dede et al., 2004). With the task, learners get a common goal, and the clues could enrich the task with a common focus of the communication. Those clues in every corner of the learning environment lead learners to explore more actively and to enjoy searching for the missing 'mosaic puzzles'. In addition, those clues are multidisciplinary by nature, which provides diverse learners with diverse choices of clues to be used, which also involve them different contribution in their collaborative learning process. In other word, a student who is good at logical reasoning, a student who is interested in biology, a student who is very sensitive to visual image, all of them will get their places for a meaningful contribution and collaboration.

Exploratory scaffolds are theoretically based on the 'anchored instruction' and 'situated cognition'. Both emphasize the importance of creating an anchor and

contexts that enable students to identify and define problems, and to pay attention to their own perception and comprehension of the problems (Cognition and Technology Group at Vanderbilt, 1993; Bransford, et al, 1990; Winn, 1993; Lave & Wenger, 1991).

Examples of exploratory scaffolds

In the River City, there are a number of shocking visual clues such as dead horses in the river or garbage in a specific area. It provokes discussion as shown below.

S1: Where are you?
S2: I am in the Tenement. Come down here, you guys!
S1: Ok, I am on my way.
S3: What's happening here?
S2: It is really dirty down here.
S1: The water looks gross.
S2: Oh my god, lots of garbage!
S4: Yuk, I see some dead fish!
S1: Dead horses!!!!
S2: How can kids swim in that dirty river?
S4: If they swim there, they must get sick!

Another outstanding example of exploratory scaffolds could be the case of Mystery at the Museum (M@M) developed by MIT Teacher Education Program. It is an augmented reality simulation game with which teams of learners collaboratively learn museum exhibits running in a museum with individual mobile devices. In this game, teams consisting of a Biologist, a Technologist and a Detective must work together to solve a museum theft crime. Its scenario says "the infamous band of Flamingo Thieves has struck again and stole a priceless object from the Museum of Science, but your team must figure out what they have stolen, how they did it, and catch the thieves before they get away."(Klopfer et al., 2005; MIT Teacher Education

Program, 2003)

Players have many different ways in which they can collect clues - including interviewing virtual characters (unique to each room within the museum), collecting clues found in exhibit halls, analyzing samples using virtual instruments, and using information from exhibits throughout the museum. Actual conversation transcription from Klopfer et al.(2005) and screen shots are given below in Fig 5.

Mom 1: We're looking for codes to help us decode this. If anyone finds stuff let us know!

Girl 2: Over here! Over here!

Mom 1: [Boy2] look in the 14th century [points to chronological history of mathematics]

Boy 2: Look Look. Water and dice like on the code.

Dad 2: [reads information about the code to himself and then applies that to the code "written" on the back of a virtual receipt] In an … hour.. [points to a part of the exhibit and speaks to the group]…it is telling him when to meet by the water. An hour after close…

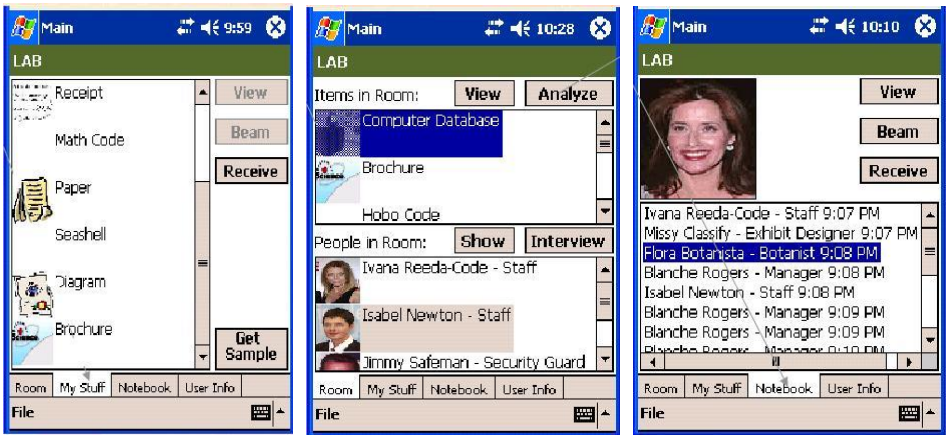

Figure 5. Mystery at the Museum screen shots.

From what we can clearly notice in the transcription, learners act just like detectives who try to decode from various information sources such as computer database, receipt, math code, Hobo code, paper, seashell, diagram and brochure shown in Fig. 5. These clues scattered around this enjoyable exploration learning environment certainly scaffold active engagement and interactions.

Conclusion

This study proposed the *Collaboration Scaffolding* and its three subtypes, *emotional scaffolds, facilitative scaffolds,* and *exploratory scaffolds.* Although extensive body of literature on CSCL and scaffolding has addressed ways to enhance individual or groups of learners' learning outcome, research communities of this field are recently focusing on the growing research need for supporting learners who could have difficulties in collaboration process itself in the new CSCL environment, and scaffolding them socially and psychologically (Kolodner et al., 2003; Davis & Miyake, 2004). We hope that this paper would be a meaningful try to respond to the need.

Further research could direct to discuss whether the collaboration scaffolding should fade when optimum interaction is once achieved. The issue of fading is on the debate among researchers since the word 'scaffolding' has its original metaphor of 'temporary' structure. Once learners get on the right track, should it disappear or not? Many researchers such as Kolodner and Pea support scaffolding without fading so that it can become a part of community's distributed intelligence (Pea, 2004). In this paper, the collaboration scaffolding could fade and could not fade. Emotional scaffolds are device that usually remain in the system, and learners can choose not to use them when they do not need them. Facilitative scaffolds provided by human - not a programmed agent - can fade as we have seen in the River City. Facilitative scaffolds embedded in PBL-Protocol did not fade. The system had the feature but didn't make those disappear based on learners' progress. This issue could also be

related to 'who should provide scaffolding', i.e. 'the agent of scaffolding' since programming appropriate fading moments for every learner and designing such intelligent systems seems not to be an easy matter yet (Davis & Miyake, 2004), and human agents such as teacher can make it fade easily based on their decision of the proper timing of fading. Future research could also direct to analyzing other successful CSCL systems and adding more collaboration scaffolding sub types, so that this consideration may be helpful for educators and developers who are interested in supporting learners' social interactions in an actual collaborative practices.

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