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Exploring Students' Knowledge Construction Strategies in Computer-Supported Collaborative Learning Discussions Using Sequential Analysis

Nurbiha A Shukor^{*}, Zaidatun Tasir, Henny Van der Meijden and Jamalludin Harun

Faculty of Education, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia // Faculty of Education, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia // Radboud University, 6525 Nijmegen, Netherlands // Faculty of Education, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia // nurbiha@utm.my // p-zaida@utm.my // h.vandermeijden@pwo.ru.nl // p-jamal@utm.my

^{*}Corresponding author

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ABSTRACT

Online collaborative learning allows discussion to occur at greater depth where knowledge can be constructed remotely. However students were found to construct knowledge at low-level where they discussed by sharing and comparing opinions; those are inadequate for new knowledge creation. As such, this research attempted to investigate the students' behaviour and their strategies to construct knowledge during online collaborative discussions. Using the combination of content analysis and sequential analysis technique, this research found that groups those being able to construct high-level knowledge tend to negotiate on shared information. Argumentation is also found to contribute for successful knowledge construction at higher-level. This study suggests triggering argumentation and emphasizing on problem-solving tasks for better knowledge construction sustainability.

Keywords

Knowledge construction, Sequential analysis, CSCL, Online learning discussion, Higher education

Introduction

Knowledge construction develops in a collaborative learning environment where students communicate by sharing information in groups for solving given tasks (Dillenbourg & Fischer, 2007; Alavi & Dufner, 2005; Crook, 1998). Knowledge construction per se, is the vivid evidence of collaborative learning taking place (Alavi & Dufner, 2005; Veerman & Veldhuis-Diermanse, 2001), as students learning in a collaborative learning environment have to make their thoughts clear (Van Boxtel, 2000).

Previous studies found that students prefer to share and compare the available information rather than progressing to construct new knowledge during collaborative discussions (Ma, 2009; Schellens et al., 2008). It shows that students tend to interact at the level of rapid consensus, where students tend to accept peers' opinions not necessarily because they agree with each other, but merely to hasten the discussion (Rimor, Rosen & Naser, 2010).

Constructing knowledge at a higher level is more important for students' learning, particularly online, because it ensures students are experiencing meaningful learning. At the high-level of knowledge construction, students externalize thought that involve arguments, justification, or decision making. Those are the attributes that help students to be critical thinkers and thereby able to construct new knowledge (McLoughlin & Luca, 2000).

Online collaboration often involves the use of discussion board as the platform to work collaboratively. Using this platform, students can negotiate opinions with group members to finally construct knowledge (Schellens et al., 2008; Beers et al., 2005; Van der Meijden, 2005). Researches indicate that students communicating in asynchronous medium posted more messages of a higher-level of knowledge construction as compared to messages in synchronous communication (Van der Meijden, 2005; Veerman & Veldhuis-Diermanse, 2001). This is because asynchronous communication provides retention time for; self-reflection (such as the time to provide opinions and reflecting information) (Veerman & Veldhuis-Diermanse, 2001), processing information (Kim, Liu & Bonk, 2005) and being aware of how group dynamics evolve (Solimeno et al., 2008).

In this study, students' behaviour of constructing knowledge will be investigated. Upon knowing their knowledge construction behaviours, a more detailed exploration will be carried out to know how they have progressed in constructing knowledge; that is, what are the strategies they used to construct knowledge. From this information, the

educators will be able to know which strategy is significant that would help the students to be able to construct knowledge particularly towards high level. As such, the following are the research objectives:

- To investigate students' behaviour of constructing knowledge in online collaborative discussions
- To identify students' strategies when constructing knowledge in online collaborative discussions
- To identify the transition state of students' knowledge construction strategies in online collaborative discussions

Literature review

Socio-cultural theory views on collaborative learning

Vygotsky suggests that individuals should be exposed to tasks which are beyond their existing knowledge and which they are unable to solve independently. Accordingly, by interacting and giving assistance with/from others, "imitation" is possible (Chaiklin, 2003). Additionally, in order to understand human learning and thinking, Bonk and Cunningham (1998) asserted that one should explore the "context and setting in which that thinking and learning occurs."

Socio-cultural theory views learning in a social context (Jeon, 2000). It describes a situation where social and individual processes are interdependent to jointly achieve knowledge construction (John-Steiner & Mahn, 1996). Nevgi, Virtanen and Niemi (2006) indicated that social interdependence variables (e.g., individualistic aspects) are highly correlated to group processes. According to John-Steiner and Mahn (1996), original works of socio-cultural importance are by Vygotsky. This author explored the idea of human activities being mediated by language and other symbol systems. While taking place in a cultural context, human activities are best explained with reference to their historical development.

Human participation in various joint activities will be exposed to wide opportunities for learning from each other, and thus forming the basis for cognitive and linguistic mastery (John-Steiner & Mahn, 1996). As such the focus of socio-cultural research is about the processes for internalization, appropriation, transmission or transformation in formal and informal settings for knowledge to be finally co-constructed (John-Steiner & Mahn, 1996).

With respect to social interaction that is central to collaborative learning, collaborative learning builds upon the socio-cultural theory where a causal relationship exists between social interaction and individual cognitive change (Dillenbourg et al., 1996). Both are interdependent for the co-construction of knowledge (John-Steiner & Mahn, 1996).

Collaborative learning is the term used to describe the learning approach aimed at constructing knowledge to solve a given task by a group of individuals of diverse cultural backgrounds (Alavi & Dufner, 2005; Crook, 1998). Collaborative learning provides opportunities to explore socio-cultural issues to a greater extent with the understanding that collaboration is a philosophy of interaction that requires individuals to be responsible for their actions where besides learning, they are committed to appreciating their friends' contributions (Panitz, 1996).

As much as socio-cultural theory highlights interaction, the value of interaction in collaborative learning is also denoted by Gerlach (1994) where collaborative learning is a naturally social act as the participants talk among themselves. Collaborative learning considers working together will result in better understanding as compared to working independently (Panitz, 1996).

Collaborative learning discussions

According to Dillenbourg (1999), the perception that collaborative learning consists of two or more people learning together does not necessarily describe collaborative learning. This is because 'two or more people' can be a group of people of up to 30 members, 'learning something' can be simply going through courses or studying specific subjects, and 'together' can be learning face-to-face or computer-mediated (Dillenbourg, 1999). However, recent literature has been found to portray collaborative learning in a more explicit way with the description that collaborative learning should be:

- a small group working together (Barkley, Cross & Major, 2005; Göl & Nafalski, 2007),
- having specific learning activities or tasks (Barkley, Cross & Major, 2005; Dillenbourg et al., 1996),
- knowledge being created (Blumenfeld et al., 1996; Crook, 1998; Alavi & Dufner, 2005; Dillenbourg & Fischer, 2007).

First of all, collaborative learning should consist of a small group of students working together. Barkley, Cross, and Major (2005) specifically mentions that groups in collaborative learning should be small, as small as in pairs. Göl and Nafalski (2007) added that a group should be small, not exceeding five members in each group. However, earlier, Dillenbourg (1999) disputed that group size, group heterogeneity and group compositions are variables that interact with each other. Different group identities have different effects on different tasks. What can be done is to explore the influence of the group's properties towards learning (Dillenbourg et al., 1996).

Also, although interacting with peers can achieve results in learning, they may not learn anything on the basis that they have nothing to work on (Dillenbourg et al., 1996). Thus, there should be specific activities that peers have to perform jointly for learning. As indicated earlier, the term 'learning' can refer to following courses or undertaking specific subjects. However, joint problem-solving is the more appropriate activity for collaboration (Dillenbourg et al., 1996). Problem solving will result in members of the group having to share ideas, consider the opinions of others' and give and receive help (Blumenfeld et al., 1996). Along the process, students will be exposed to more complex skills of planning, monitoring and evaluating progress (Blumenfeld et al., 1996). Problem solving has been chosen as the type of task for collaborative learning in numerous studies (see works by Chung et al., 2008; Puntambekar, 2006; Beers et al., 2005; Cheung, Tan & Hung, 2004).

The ultimate goal for collaborative learning resides within the co-constructed knowledge as a result of learning (Dillenbourg & Fischer, 2007). Upon sharing information among group members and reaching a common ground, knowledge is constructed and later internalized at an individual level (Beers et al., 2005). Collaborative learning values the processes that took place during learning, which is before a specific learning outcome is achieved. It was perceived that collaborative learning, as being central to socio cultural theory, is a result of interaction between individuals (Vygotsky, 1978).

Central to collaborative learning is knowledge construction where the collaborative learning approach aims at co-constructing knowledge upon sharing information in groups for solving given tasks (Dillenbourg & Fischer, 2007; Alavi & Dufner, 2005; Crook, 1998). Knowledge construction is vivid evidence of collaborative learning taking place (Alavi & Dufner, 2005).

In Malaysia, students construct knowledge using strategies such as questioning, clarifying or giving support (Mansor & Abd Rahim, 2009). However, students' behaviour of constructing knowledge is dependent on the online platform being used. For example, when using Facebook as the medium of constructing knowledge, 47.1 percent of the students were found to be able to clarify knowledge by elaborating on ideas and thoughts (Idris & Ghani, 2012). However, when using online discussion boards, such as in Quickplace, students were found to be able to construct knowledge but were limited to seeking and giving opinion as they preferred to impart knowledge. There is no indication of new knowledge being constructed (Hong & Lee, 2008).

The following discussion will provide a better insight on how collaborative learning will engage learning through social knowledge construction.

Students' knowledge construction

Knowledge construction (KC) represents one of the processes for indicating cognitive activities. It can take the forms of, namely: the provision of students' behaviour of seeking, interpreting, analyzing and summarizing information, critiquing and reasoning through various options and arguments and making decisions in online discussions (Zhu, 2006).

Van der Meijden (2005) affirmed this type of provision for cognitive activities by analysing students' elaborations in synchronous and asynchronous discussions. She stated that students' KC is indicated by their behaviour of "posing of comprehension questions requiring explanations, the supply of answers with arguments or justification, the

presentation of new ideas accompanied by explanation, and the acceptance or rejection of ideas coming from others accompanied by arguments” (Van der Meijden, 2005).

In the context of CSCL, knowledge construction is perceived as the eventual outcome of learning. However, the processes of construction and reconstruction are complex and are influenced by interconnected factors (Onrubia & Engel, 2009). This stance was shared by Beers et al., (2005) who indicated that, for unshared knowledge to be finally constructed, intermediate processes such as externalization, internalization, negotiation and integration take place.

Students with diverse expertise need to reach common ground for knowledge to be constructed (Puntambekar, 2006). Within this intermediate process lies the fundamental idea of collaborative learning on how divergent ideas come to work together for knowledge construction (Puntambekar, 2006). Over this concern, Schellens and Valcke (2006) attempted to foster knowledge construction among university students through asynchronous discussion groups using the information processing approach to learning. They theorized that for knowledge to be constructed, an individual’s cognitive processing will be actively engaged. Higher knowledge construction is operationalized as the higher level explicitation type of comment and higher level evaluation type of comment. They found that students in discussion groups are very task-oriented, where higher proportions of advanced phases of knowledge construction are observed (Schellens & Valcke, 2006). Previous discussions demonstrated that students’ knowledge construction can be fundamentally explored from the way they expressed themselves in written communication or discourse.

Analysing students’ knowledge construction strategies in CSCL groups

There are various methods applied by the researchers to understand students’ knowledge construction in CSCL discussions. The common method would be content analysis; where by assigning unit of analysis to the posted messages, the messages can be coded using specific coding scheme and conclusion can be drawn from the findings. For example, Van der Meijden (2005) explored students’ knowledge construction during CSCL discussions and categorized the students into having high or low level of knowledge construction. Although students were discussing in groups, this study did not explore on how the students work as a group to strategize for knowledge construction. A recent study by Lan et al., (2012) explored students’ knowledge construction and their behavioural patterns when discussing in groups using content analysis and sequential analysis. They explored students’ knowledge construction on individual basis but did not compare how a specific group put up strategies to construct knowledge. Other similar studies used sequential analysis to investigate knowledge construction upon using specific tool for learning (see Lin et al., (2012)). However, the findings of these studies were dependent on the tools that they developed to trigger knowledge construction and did not focus on how CSCL group functions.

Research on better understanding on how the students strategize to construct knowledge particularly when discussing; in collaborative group is sparse. There is a need for understanding how group functions during CSCL discussions; that is to learn how the group apply strategies to construct knowledge. Mazzolini and Maddison (2007) pointed that the educators have difficulties in identifying the correct moment to intervene in order to improve the quality of online discussions. As such, this study will serve as an important indicator for educators in conducting online learning discussions particularly when using collaborative learning as the instructional strategy.

Method

Participants

The participants were 20 students enrolled in the subject Web-based Multimedia Development at a university in southern Malaysia. There were five groups consist of four members in each group. All the students were familiar with the online discussion environment because they have used the same platform for other subjects as well.

CSCL problem-solving tasks for discussion

Students in the course have to solve five problems in groups related to the Web-based Multimedia Development subject. The problems were real-life problems that the students have to face whenever designing educational

websites as related to this course. Students were given two weeks to solve each problem through group discussions in the course discussion board. Students were not assigned to any particular role in groups to maintain collaboration to occur as natural as possible. The instructor gave scaffold to group discussions such as inviting participation and giving clues. The students solved each of the problems in their own group in different discussion section. The following are the tasks that all the students have to solve in their groups in order:

- Week 2 - Problem: Error 404,
- Week 4 - Problem: Problems in website design,
- Week 6 - Problem: Pictures in a website: why my picture did not appear in web browser?
- Week 8 - Problem: Different views in Opera, Mozilla, and Google Chrome: What happen to my website?
- Week 10 - Problem: Which media fits in website? Which media does not fit?

Research design and procedures

This research adopted a case study research design to answer questions on how students' construct knowledge during CSCL discussions. Next, comparison is made to the CSCL groups' strategy in constructing knowledge. The content analysis and sequential analysis technique were used to finally construct transition state diagrams of the CSCL groups.

Content analysis procedures

To investigate students' behaviour of constructing knowledge in CSCL discussions, this study used content analysis technique to analyse students' discussion scripts. Content analysis is applied to students' discussion scripts while discussing in online learning discussion board based on a coding scheme. Upon characterization based on the coding scheme, this study applied unit of meanings for objectivity. This research adopted the coding scheme by Van der Meijden (2005) who developed the coding scheme to evaluate students' knowledge construction in asynchronous and synchronous online discussions as in Table 1.

Table 1. The coding scheme for analysing students' knowledge construction in CSCL discussions

Cognitive: Asking questions (Cognitive 1)		Examples of use
CHV 1	Asking questions that do not require an explanation (facts or simple questions)	<i>Has the problem been solved?</i> <i>How many types of images are they?</i>
*CHV 2	Asking questions that require an explanation (comprehension or elaboration)	<i>You have explained all the units for developing the website, but which one is preferable and why?</i> <i>Do you have any idea on solving the problem?</i> <i>Can we do anything to fix this?</i>
CHVER	Verification or asking for agreement	<i>Is it true?</i> <i>Am I explaining correctly?</i>
Cognitive: Giving answers (Cognitive 2)		
CHG 1	Answering without explanation	<i>There are 3 types of images.</i> <i>The problem has been solved.</i> <i>.jpeg is different than .png image.</i>
*CHG 2	Answering with explanation (using arguments or by asking a counter-question)	<i>It means that not all computer resolution is the same because..</i> <i>The information shows that ..</i>
Cognitive: Giving information (Cognitive 3)		
CI 1	Giving information (an idea or thought) without elaboration	<i>I paste the information from the internet as presented below ..</i> <i>From what I see, both images look the same.</i>
*CI 2	Giving information (an idea or thought) with elaboration	<i>I guess the alternative way to solve this is by ..</i> <i>From the example that I obtained from the internet below, they say that ..</i>

CIT	Referring to earlier remark/information	<i>Some of the discussion said so because .. We often have the same problem.. This problem has occurred to me before .. Based on Aishah's explanation ..</i>
CIE	Evaluating the content (summarizing/concluding)	<i>So, the verdict is.. We can conclude that..</i>
AN	Accepting contribution of another participant without elaboration	<i>I agree. You might be true.</i>
*AY	Accepting contribution of another participant with elaboration	<i>I agree with you because.. Aishah is right because ..</i>
NAN	Not accepting contribution of another participant without elaboration	<i>I don't think that is the cause of the problem. I don't think that is right.</i>
*NAY	Not accepting contribution of another participant with elaboration	<i>That might not be the problem because .. I disagree with you because ..</i>

Note. All codes with (*) indicates high-level cognitive contributions.

For reliability purposes, two raters coded 55 messages in 6 continuous coding sessions. "Message" is the term used to describe the raw discussion scripts posted by the students. In every session, we coded the messages individually and then compared our codes. We discussed, compared and contrasted on our codes to finally reach a common agreement on the suitable code for each meaning in the students' messages. The processes were repeated until we finally gathered all the messages and coded them in the final coding session.

In the final coding session, the number of unit of meanings was calculated to clarify that both coders had the same number of segments. We used the term 'segment' to signify discussions scripts with specific unit of meaning. There were a total of 105 segments from the 55 messages.

Next, we compared the codes on the segments to look for agreement or disagreement. From 105 segments, it was found that both coders agreed upon 89 segments which accumulated 84.76 percent of agreement. Coding session resulted in 84.76 percent of inter-coder agreement which is higher than 83 percent as obtained by Paulus (2009) and it is higher than 81.4 percent (Van der Meijden, 2005) when inter-rater reliability was calculated; and thus acceptable. The resulting kappa value was 0.745 where Fleiss (1981) and Capozzoli et al. (1999) stated that a Kappa value of 0.40 – 0.75 as intermediate to good. This indicates that both coders have good mutual understanding about applying the codes to students' discussion scripts.

Finally, students were identified to be either in the group with high level of knowledge construction (H), high-low level of knowledge construction (HL) or low level of knowledge construction (L). The identification of groups is summarized in Table 2. We compared the frequency of codes of high-level cognitive contribution (as indicated with "*" in Table 1) with the frequency of low-level cognitive contribution. Groups that posted more high-level codes than low-level codes are categorized as "H" group, groups with more low-level codes than high-level codes are categorized as "L" group and groups with same frequency of codes in high and low-level are categorized as "HL" groups.

Table 2. Group identification based on level of knowledge construction

Details	Group type
# High-level cognitive contribution > # Low level cognitive contribution	H
# High-level cognitive contribution = # Low level cognitive contribution	HL
# High-level cognitive contribution < # Low level cognitive contribution	L

Sequential analysis procedures

To further understand students' strategies in constructing knowledge, this research used sequential analysis technique. Sequential analysis technique shows the sequences of students' action when constructing knowledge. The coded 292 segments from content analysis underwent a series of sequential transition matrix calculation (Bakeman & Gottman, 1997). This research considers a z-score greater than 1.96 as the sequence of a row and a column as being statistically significant ($p < 0.05$) (Bakeman & Gottman, 1997). Finally, the significant sequences were gathered to

construct the transition state diagram that illustrates the different students' strategies to construct knowledge in CSCL discussions for groups with different levels of knowledge construction.

Results

This study investigates students' behaviour when constructing knowledge during problem solving discussions using content analysis and sequential analysis techniques. The percentages of the coded segments from content analysis procedures are shown in Figure 1. There was no student who posted messages from the code CHV 1 and NAN thus the result is not displayed in the figure.

Generally, students posted most messages at the low-level of knowledge construction. Highest percentage is accumulated at the CI 1 code (25.81%) which contributed almost half of the percentage in low-level of knowledge construction. The CI 1 code was most demonstrated when students in this research "paste" the information directly from internet resources without giving elaboration on the information during online discussion. However, some students made summary from the information that they shared. For example, Student S16 posted the following message:

Student S16: Oh my friends, lets' check here:

Many people ask "Why is my website design different when using Mozilla and IE?" How do I get .. (CI 1).

Summary: It is said (from the above information) that this problem exists because of the validation process that used HTML and XHTML version (CIE).

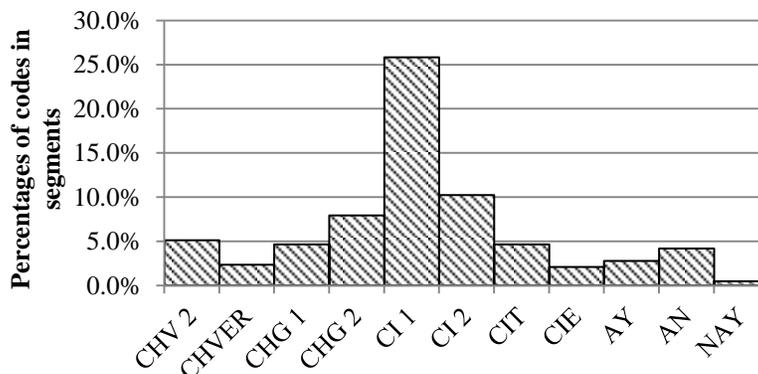


Figure 1. Distribution of students' knowledge construction behaviour during problem solving in CSCL

In this research, it is also found that the higher-level of knowledge construction such as CHV 2, CHG 2, AY and NAY are difficult to reach due to low percentages. However, looking at the bright side, there are in fact argumentations (AY and NAY) going on and active question and answer sessions (CHV 2 and CHG 2) although at low percentages. For example, Student S2 posted the following:

Student S2: I'm quite confused as to which one is better for a website. Can anyone tell me the quality difference between .gif and .swf format? I try to search for .. (CHV 2).

With the exposure to CSCL discussions, students in this study were able to display behaviors that reflected high-level of knowledge construction such as "asking questions that require an explanation (comprehension or elaboration)" (CHV 2), "answering with explanation (using arguments or by asking a counter-question)" (CHG 2), "sharing information with elaboration" (CI 2), "accepting information with elaboration" (AY), and "not accepting information by providing elaboration" (NAY). Students' pattern of contributions in collaborative groups was identified as in Table 3.

From Table 3, there were three groups identified as having high level of knowledge construction (H), that is, more than half of the groups. There is one group categorized as the “L” group. To further understand how these groups construct knowledge, sequential analysis was carried on the respective groups. Table 4 presents an example of the z-scores obtained from the “H” groups. From Table 4, each row represents a starting knowledge construction strategy and each column represents the follow-up strategy. The significant sequence is the sequence with z-score of more than 1.96 (Bakeman & Gottman, 1997).

Table 3. Group categorization based on levels of knowledge construction

Group	#Low-level cognitive contribution	#High-level cognitive contribution	Group type
A	51	17	L
B	16	21	H
C	41	50	H
D	19	27	H
E	25	25	HL
Total	152	140	

Table 4. Example of z-score for the ‘H’ groups

z	CHV2	CHVER	CHG1	CHG2	CI1	CI2	CIT	CIE	AN	AY	NAY
CHV2	-0.19	-0.43	1.06	0.40	-1.51	*2.34	0.71	-0.82	-.082	-1.04	-0.43
CHVER	-0.51	-0.19	-0.47	0.80	0.11	-0.69	-0.53	-0.35	-0.35	1.96	-0.19
CHG1	0.06	-0.38	-0.97	1.64	0.87	-1.42	-1.09	-0.73	*2.34	-0.92	-0.38
CHG2	-0.16	1.33	0.08	0.79	-0.69	0.72	-1.02	0.94	-1.17	0.22	-0.62
CI1	-0.26	-0.97	1.42	0.36	0.67	-0.75	-1.59	1.48	-0.18	-0.32	-0.97
CI2	-0.68	-0.55	-1.39	-1.67	-1.95	1.23	*3.25	-1.04	1.25	*2.38	1.57
CIT	-0.26	*2.03	0.95	-0.44	1.21	-0.90	-0.34	-0.85	-0.85	0.01	-0.45
CIE	0.81	-0.27	-0.67	-1.10	0.15	-0.99	0.73	1.63	1.63	-0.64	-0.27
AN	-0.66	-0.24	-0.61	-1.00	*2.44	-0.90	0.94	-0.46	-0.46	-0.58	-0.24
AY	1.30	-0.37	-0.92	0.17	-0.24	0.46	0.08	-0.69	-0.69	-0.88	*2.58
NAY	*2.22	-0.15	-0.38	-0.63	0.60	-0.56	-0.43	-0.29	-0.29	-0.37	-0.15

Table 5 presents the summary of significant sequence for “H” groups, “HL” group and “L” group respectively at $p < 0.05$.

Table 5. The significant sequences according to group type

Group type	Significant sequence	z - score
High level knowledge construction (H)	CHV 2 -> CI 2	2.34
	CHG 1 -> AN	2.34
	CI 2 -> AY	2.38
	CIT -> CHVER	2.03
	AN -> CI 1	2.44
	AY -> NAY	2.58
	NAY -> CHV 2	2.22
High-low level of knowledge construction (HL)	CHG 2 -> CHVER	2.06
	CI 2 -> CIT	3.08
	AY -> CHV 2	3.89
Low level of knowledge construction (L)	CHV 2 -> CHG 1	2.35
	CHV 2 -> CHG 2	2.35
	CI 2 -> AN	2.69
	CIE -> CHV 2	3.19
	CIE -> AY	2.69

Students in different type of group were found to apply different strategies to construct knowledge during online discussions. Comparison was made between the transition state of group “H”, “HL”, and “L” as presented in Figure 2, Figure 3 and Figure 4 respectively. There were seven significant sequences for the ‘H’ groups with most

Using argumentation for knowledge construction sustainability

This study found that different groups showed significant different strategies when constructing knowledge. The “L” group focused more on answering questions and the strategy ended at that point (Cognitive 2). Although there were strategies that involved giving detailed information, they lacked the argumentation elements (AY, AN and NAY) even though they did agree on statements and elaborate on them. Agreeing on statements seems insufficient for the group to reach high level of knowledge construction as a group. According to Howard (1996), by arguing, justifying, explaining and providing evidence, students are self-regulating and hence, they are communicating at a high level of cognitive engagement. Likewise, argumentation is always needed to learn in conjunction with problem-solving.

The “H” groups have more thorough discussions as compared to the other groups. According to the transition state diagram, they negotiate, compare and contrast before proceed to the next strategy for constructing knowledge. Interestingly, despite other high level codes, the argumentation codes (AY, AN and NAY) were the codes that differentiate “H” groups than the other groups. For example in “H” groups, when they came into argument, they provide justification and give information (sequence AN – CI 1). Accordingly, whenever they disagreed with information, they proceed with asking questions that require elaborations (sequence NAY – CHV 2).

This study suggest that triggering argumentation is very important and it was the strategy that maintained the “H” groups to have high-level of knowledge construction as compared to the other groups. As such, to ensure group functioning, educators could assist discussions to promote argumentation such as by asking questions or to provoke opinions during the discussions.

Problem-solving tasks for CSCL discussion

This study found that problem solving discussion can influence students’ behaviour of constructing knowledge in groups. Although this study showed that the highest frequency during online discussion is CI 1, all the groups (“H,” “HL,” and “L” groups) were found to be able to apply strategies that involved high-level of knowledge construction codes such as AY and CI 2. This might due to the authentic problem solving task given to the students that requires them to spend extra effort to successfully solve the problems. Collaborative problem solving will exposed students to various solutions and they have to tackle different opinions. They are also able to determine their own attitude while dealing with problems (Rahikainen, 2002). It is similar to results reported by Hurme and Järvelä (2001) that problem solving is the appropriate tasks for collaboration because it helps to reveal the metacognitive processes as an important output of learning. However, problem solving tasks for CSCL discussion has to be properly design so that it will trigger argument. In this study, argumentation is found to play one of the primary roles towards students discussing at the high level of knowledge construction. Possibly, organizing debates would yield more groups functioning at the high level of knowledge construction.

Limitations and future research recommendation

This study has several limitations. Firstly, this study is interested in discovering how students construct knowledge while discussing in CSCL. Thus, the results of this research only came from the data obtained from online discussion for in-depth understanding. Categorization of students’ knowledge construction in groups also relies heavily on their contributions in online learning discussions. The results of other students’ activities in CSCL is has not taken into account in the research. However, it is important to know that knowledge construction is difficult to create and sustain, thus exploring the facets that could trigger knowledge construction can be considered a success. Other than that, this study did not consider the motivational aspects and the group composition (gender) that might also influence the group strategies when constructing knowledge. This study is limited to understanding how CSCL group can function when constructing knowledge. Further research should explore in-depth on the influences of different variables towards students’ strategy of constructing knowledge particularly when solving problems.

Conclusions

Conclusively, this research used content analysis and sequential analysis to explore students’ strategies when constructing knowledge in online discussions. After the analysis, students’ knowledge construction were explored

with respect to their CSCL groups and transition state diagrams were drawn according to the group's type of either "H," "HL," and "L." It was found that students still struggle to construct knowledge that involved elaborations. There were significant differences in application of strategies to construct knowledge in groups. The "H" type of groups focussed more on negotiation of information by arguing and debating while the "L" group was comfortable with asking-answering sessions. We also discovered that for more comprehensive knowledge construction during CSCL discussions, argumentation is one of the crucial factors. As such, the problem solving tasks for CSCL should trigger argumentation elements such as arguing, justifying, explaining and providing evidence.

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