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Using Code-Recode to Detect Critical Thinking Aspects of Asynchronous Small Group CMC Collaborative Learning

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Abstract

This article empirically validates an existing content analysis scheme and addresses a main concern of researchers about text-based, online transcripts in the form of code-recoding by mapping our scheme to the practical inquiry, cognitive presence model's five phases directly to realise higher-order thinking or critical thinking aspects for our software engineering students at London Metropolitan University. Two case studies are presented from final year undergraduate students. We also evaluated a semi-structured CMC environment called SQUAD, developed in-house for scaffolding small group collaborative learning. We argue that the empirical study conducted with software engineering students in Hong Kong and London gives an indication that critical thinking or higher-order thinking certainly exists within online collaborative learning teams where knowledge emerges and is shared. We claim that responses in the integration and resolution categories are more pertinent to critical thinking or higher-order thinking in the context of online, small group, collaborative learning environments when using the cognitive presence model as a framework for measurement purpose.

Keywords: asynchronous, computer-mediated communication (CMC), cognitive presence, content analysis, code-recode, inter-rater reliability, problem-based learning, synchronous

Introduction

A number of researchers have been concerned with proliferation of existing content analysis schemes for online discourse with respect to text-based synchronous/asynchronous learning environments. A number of these schemes have been developed for a particular purpose and have either never been used again or researchers are unwilling or reluctant to reuse these schemes due to lack of confidence in their theoretical underpinning or the subjectivity of such (Arbaugh, 2007; DeWever, Schellens, Valcke, & Van Keer, 2006; Oriogun, Ravenscroft, & Cook, 2005; Rourke & Anderson, 2003) schemes.

Consequently, there is now a proliferation of schemes used for content analysis of computer-mediated communication (CMC) text-based discourse and a need for researchers to start validating the reliability and choice of existing schemes by testing such schemes for their robustness, validity, and reliability.

In this article, we adopt an existing content analysis scheme called the cognitive presence model (Garrison, Anderson, & Archer, 2001) as a framework to validate our ongoing research on the SQUAD approach, a small group collaborative learning environment developed at London Metropolitan University for scaffolding students' learning.

The SQUAD approach to CMC discourse invites students to post messages based on five given categories, namely, *Suggestion, Question, Unclassified, Answer and Delivery.* The approach to online discourse adopts problem-based learning (Barrows, 1996; Bridges, 1992; Oriogun, et al., 2002) as an instructional method with the goal of solving real problems by (Oriogun, 2003):

- Creating an atmosphere that will motivate students to learn in a group setting online (where students are able to *trigger* discussion within their respective groups);
- Promoting group interactions and participation over the problem to be solved by the group online (where students can *explore* various possibilities within the group by actively contributing to the group);
- Helping learners to build a knowledge base of relevant facts about the problem to be solved online (where students can begin to *integrate* their ideas to influence others within the group);
- Sharing newly acquired knowledge with a group online with the aim of solving the given problem collaboratively and collectively (where students can *resolve* issues relating to the assigned work to be completed collectively and cooperatively);
- Delivering various artefacts' leading to a solution or a number of solutions to the problem to be solved online (where students can *integrate* and *resolve* the problem to be solved collectively and cooperatively).

We have chosen to validate the SQUAD approach using the cognitive presence model (Garrison, Anderson, & Archer, 2001) as a framework because the definition and use of *trigger*, *exploration*, *integration*, and *resolution* is compatible with SQUAD approach usage of these same terms.

The SQUAD category *S* described above is focused on what the group has to deliver for their group coursework and does not necessarily deal with significant personal revelation. It also encourages students to initiate, continue, or acknowledge interpersonal interactions and "warm" and personalize the discussion by scaffolding/engaging comments that connect or agree with, thank or otherwise recognize someone else, and encourages or recognizes the helpfulness, ideas, and comments, capabilities, and experience of others.

The phases of the *Practical Inquiry* model capable of being mapped to SQUAD category *S* are *Triggers* and *Exploration* (see Table 3 for SQUAD mapping of cognitive presence phases).

The SQUAD category *Q* is a form of words addressed to a person in order to elicit information or evoke a response. An example of a *question* within the SQUAD framework is when students seeks clarification from the tutor or other students in order to make appropriate decisions relating to the group coursework (Oriogun, 2003). The phases of the *Practical Inquiry* model capable of being mapped to SQUAD category *Q* are *Triggers* and *Exploration* (see Table 3 for SQUAD mapping of cognitive presence phases).

The SQUAD category *U* is normally not in the list of categories of messages stipulated by the instigator of the task at hand. This tends to happen at the start of the online postings. Students may be unsure of what the message is supposed to convey. In most cases, it falls within one of the four classified categories (Oriogun, 2003). The phase of the *Practical Inquiry* model capable of being mapped to SQUAD category *U* is *other* (see Table 3 for SQUAD mapping. of cognitive presence phases).

The SQUAD category *A* is a reply, either spoken or written, to a question, request, letter, or article. Students are expected to respond to this type of message with a range of possible solutions /alternatives. The SQUAD category *S* is the process whereby the mere presentation of an idea to a receptive individual leads to the acceptance of the idea, and

students engage with other students within their coursework groups by offering advice, a viewpoint, or an alternative viewpoint to a current one (Oriogun, 2003).

The phases of the *Practical Inquiry* model capable of being mapped to SQUAD category *A* are *Triggers* and *Resolution* (see Table 3 for SQUAD mapping of cognitive presence phases).

The SQUAD category *D* is the act of distribution of goods, mail etc. This is where students are expected to produce a piece of software at the end of the semester. All the students have to participate in delivering aspects of the artifacts making up the software (Oriogun, 2003).

At this point, students may show their appreciations to part of the group coursework deliverable by responding with comments with real substantive meaning. The phases of the *Practical Inquiry* model capable of being mapped to SQUAD category *S* are *Integration* and *Resolution* (see Table 3 for SQUAD mapping of cognitive presence phases).

We present two case studies, the first from our Hong Kong-based students and the other from their London based counterparts. Both studies were conducted during Semester 1 of the academic year 2007-2008.

We have also seized the opportunity in this article to evaluate the current SQUAD software prototype with the help of a professional IT Consultant, and this evaluation is summarised within the body of this article.

Asynchronous and Synchronous Online Communication

Computer-mediated communication is also sometimes referred to as Networked Learning, Asynchronous Learning Networks, Computer Mediated Discussion, or just Computer Conferencing.

This mode of modern communication medium allows students and their tutors to exchange messages via networked computers synchronously (real time communication) and asynchronously (time-delayed communication) with the aid of tools such as chat rooms, newsgroups, email, virtual learning environments (VLEs) bulletin board systems (BBS), interactive websites, etc.

In general, text-based interactions tend to be asynchronous. Asynchronous, text-based interaction can be seen as being disadvantageous to teams or groups of online participants, as there can be a perceived isolation, referred to as *transactional distance*, (Moore, 1991).

Synchronous (real time communication) discourse online, on the other hand, may include video, audio, sharing of documents via downloading and uploading, sharing of experiences, and cognitive engagement (Oriogun, Ravenscroft, & Cook, 2005). Henri (1992) referred to online communication, in general, as “a gold mine of information concerning the psycho-social dynamics at work among students, the learning strategies adopted, and the acquisition of knowledge and skills” (p. 118).

Content Analysis of Online Discourse Theoretical Underpinning

Anderson, Rourke, Garrison, and Archer (2001) define content analysis as “a research methodology that builds on procedures to make valid inferences from text.” (p. 10). Researchers wanting to understand the underlying cognitive engagement of participants within small collaborative groups online tend to use Henri’s (1992) protocol. Unfortunately, Henri’s protocol is based on a cognitivist approach to learning, which has been found to be inadequate when there is a need to go beyond just gathering quantitative data about number of students’ postings to judge the quality of interaction (Meyer, 2003).

Critical thinking underpins Bullen (1997) instrument as well as that of Newman, Webb, and Cochrane (1995). Cognitive and metacognitive knowledge underpins the instrument of Henri (1992). Social constructivism in terms of knowledge construction underpins Gunawardena, Carabaje, and Lowe's (1997) instrument as well as that of Veerman and Veldhuis-Diermanse (2001). Social constructivism in terms of perspective taking is the theoretical basis of other instruments including Veldhuis-Diermanse and Järvelä (Järvelä & Häkkinen, 2002; Veldhuis-Diermanse, 2002).

The theoretical basis of Zhu's (1996) instrument is theories of cognitive and constructive learning and Fahy's (2000) instrument is based on social networking theory (interaction exchange pattern). Garrison et al. (2000) community of inquiry framework has been the theoretical basis of a number of recent instruments including Rourke et al. (1999) social presence, Garrison et al. (2001) cognitive presence, Anderson et al. (2001) teaching presence, and more recently, Oriogun, Ravenscroft, and Cook's (2005) SQUAD approach to cognitive engagement. Lockhorst et al. (2003) instrument is based on social constructivism (learning strategies), and Pena-Shaff and Nicholls' (2004) instrument is grounded in social constructivism (knowledge construction).

The common denominator of these theories is they all have knowledge construction, critical thinking, cognitive engagement, and teaching and learning strategies as their main focus. This is particularly relevant to this article, as we are trying to detect latent meaning of higher order thinking or critical thinking in small group, collaborative learning environment.

Furthermore, a number of the theories rely heavily in inter-rater reliability measure when "a complete message" is used as the unit of analysis with respect to content analysis. In the empirical study contained in this article, we use an alternative inter-rater measure commonly referred to as code-recode. It is customary for the same person to perform the initial coding, then after say, three months, recode the same transcripts before calculating inter-rater reliability value.

In the particular context of this study, students performed the initial coding through semi-structured message transcripts; thereafter, the instructor/tutor cleans the transcripts by recoding the initial transcripts in order to ascertain that the students are indeed coding the transcripts as they were instructed at the start of the initial coding session. We then refer to this recoded transcript as the clean and final transcript with which we can rely and, consequently, detect aspects of our students' critical thinking without any requirements for inter-rater reliability measure as previously explained by Oriogun (2006, p. 31).

A number of CMC content analysis researchers (Oriogun, Ravenscroft, & Cook, 2005; Rourke & Anderson, 2004; Stacey & Gerbic, 2003) have suggested that existing schemes such as Henri's (1992) protocol, Garrison, Rourke, and Anderson's (2001) Cognitive Presence model, Oriogun, Cook, and Ravenscroft's (2005) Transcript Reliability Cleaning Percentage (TRCP), Fahy's (2005) Transcript Analysis Tool (TAT), Oriogun's (2003) and Oriogun, Ravenscroft, and Cook's (2006) SQUAD and SQUAD direct mapping of the Cognitive Presence model, etc. should be used and to further validate such schemes before adoption.

Analysis of the cognitive presence model's category termed "other," Garrison et al. (2000, 2001), based on Bales' (1950) Interaction Process Analysis (IPA) method for analyzing the "systems of human interaction" (p. 257) demonstrates that it is possible that those software engineering students whose responses fall under this category of "other" are experiencing what Bales' termed "social economical positive and negative reactions," specifically "tension management" (Bales, 1950).

The purpose of this article is to further utilise existing content analysis theoretical underpinning to explore inter-rater reliability measure of online discourse. Using the practical inquiry model's cognitive presence in terms of code-recode of a semi-structured approach to

a small group collaborative learning environment, namely the software prototype implemented at London Metropolitan University (Oriogun & Ramsay, 2005), we captured undergraduate and postgraduate computing students' cognitive engagement (Oriogun, Ravenscroft, & Cook, 2005) using the SQUAD approach.

Method

The CMC transcripts of two groups of students undertaking a final year software engineering course in Hong Kong and London have been examined. We used our previous direct mapping of the cognitive presence model (Garrison, Anderson, & Archer, 2001) with the SQUAD (Oriogun, 2006; Oriogun, Ravenscroft, & Cook, 2006) to realise the salient critical thinking aspects of these students.

With respect to our Hong Kong students, lecture notes were uploaded online from the beginning of the semester, and a local tutor facilitated the delivery of the lecture materials over the course of the semester.

We monitored the progress of the London-based students on a face-to-face basis and through our in-house, semi-structured, online messaging software prototype called SQUAD (Oriogun, 2003; Oriogun, 2006; Oriogun, Ravenscroft, & Cook, 2005). Hong Kong students were monitored entirely through SQUAD software prototype by the first author and their local tutor. The five students in this group posted 62 SQUAD online messages during the first semester of the academic year 2007-2008. There were six London-based students, and they posted 89 SQUAD online messages during the same semester.

Undergraduate and postgraduate students at London Metropolitan University have used the in-house SQUAD prototype over the past four years. In this section, we briefly summarise an expert evaluation of the current version of our prototype by an IT Usability Consultant, specializing in systems integration, technology and user experience. The SQUAD software prototype is able to calculate students "online learning levels of engagement" (Oriogun, 2003) as well as the statistics relating to the type and number of messages posted by each student within their group.

Only the Administrator has access to the all the SQUAD statistics and all of the groups on the module. The Administrator interface of SQUAD v 2.0 is designed to be entirely separate from the general user section. It is implemented as a web page generated from a single Java Servlet Pages file upon the server. Client-side JavaScript is used to allow the Administrator to navigate between information pertaining to the various groups and users within the system. The Administrator can choose either to make a notice readable by a particular group or by all groups simultaneously.

In terms of the Administrative interface being "aesthetically pleasing," it was suggested that more meaningful contrast between screen elements should be provided for groups, users, notices, my account details, create group, and logout options (Galitz, 2002). It was recommended that screen elements and group options should be aligned also to use colour coding and graphics to simply represent grouping. Figure 1 shows the Administrator Interface of the current SQUAD prototype.

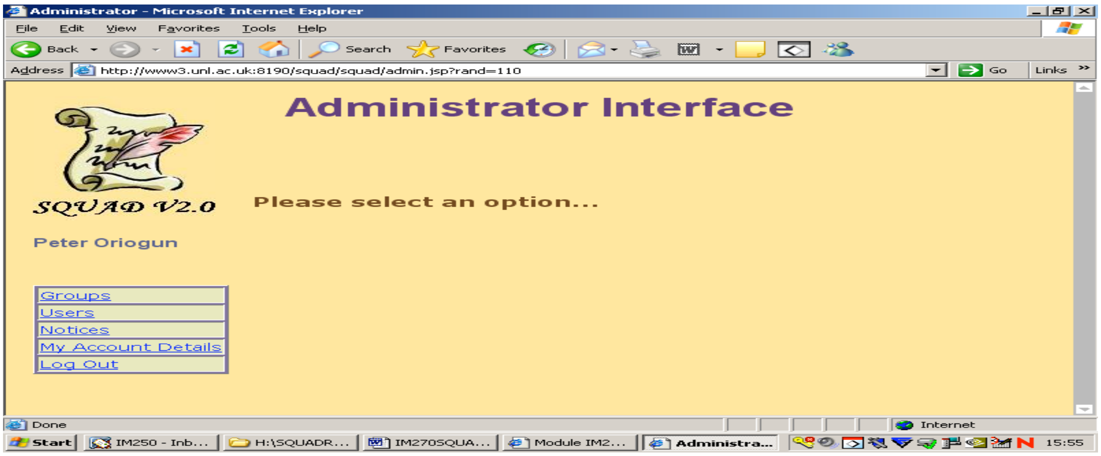

Figure 1. **Administrator interface of the SQUAD environment**

In terms of clarity, the interface needs to be visually, conceptually, and linguistically clear. This can be achieved by making use of visual elements, functions, metaphors, words, and text (Galitz, 2002). It was recommended that the user(s) should be able to grasp a clear understanding of what the application allows them to do without needing to interact with the application previously; furthermore, the disorientation should be reduced. It was further recommended that consideration should be given to "user compatibility" in terms of user needs, and tasks and actions must follow logical sequence of events.

The sequential options within the navigation menu should align with what each of the user groups (Student/Administrator) are likely to do or perform (Barfield, 1993). Figure 2 shows the "Student" Interface of the current SQUAD prototype.

In summary, it was recommended that we should provide an easy exit with visual cues task/action processing for the user (Galitz, 2002) and that help buttons more easily accessible and consistent within the prototype were needed, together with error messages that inform the user of an error and recovery processes were recommended.

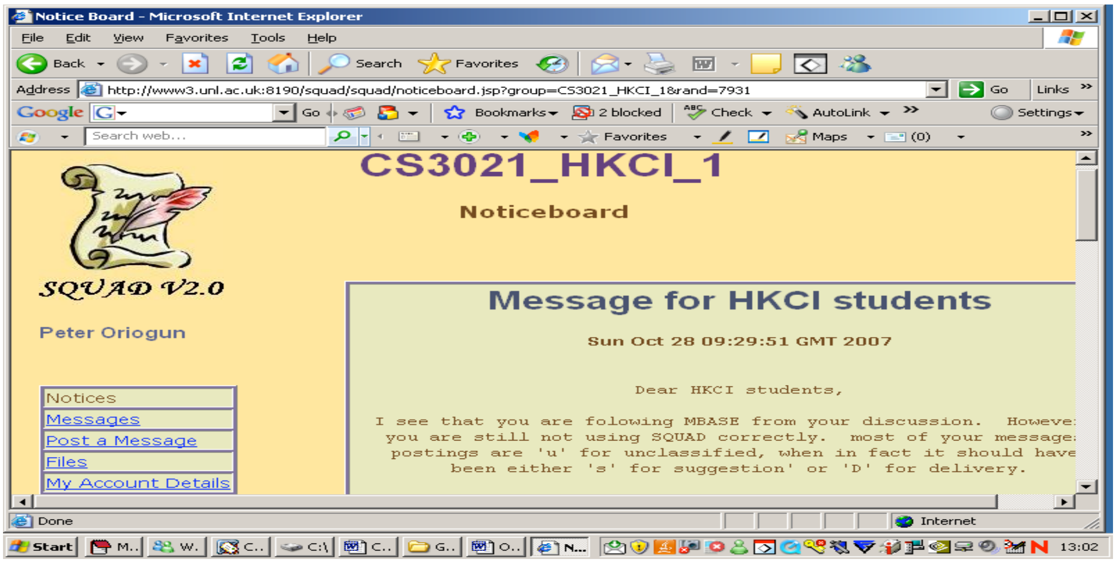

Figure 2. **Students' interface with the SQUAD environment**

Our usability consultant also recommended that we use language and phrases familiar to our students in order to allow interactivity for rapid processing by experienced users whist supporting novice users (Miller, 2002). In addition, it was recommended that navigation options should be clear and consistent; table of contents should be provided to explain each option; and backward links should also be provided for users to easily return to their starting point (Galitz, 2002). It is our intention within the department to take these recommendations on board when we develop the next version of SQUAD. Figure 2 shows the students' interface within the SQUAD environment.

The two groups of students chosen for our study were told that they must choose a SQUAD category for each message they send to their group members throughout the semester. Both groups were given access to the SQUAD environment roughly from early October 2007 until mid January 2008. Table 1 shows the code-recode of the Hong Kong software engineering students' 62 message transcripts during semester one of 2007-2008. Figure 3 shows a detailed message sent via the SQUAD environment to the Hong Kong students specifically, after using the SQUAD environment to facilitate the negotiation and reconciliation of their group coursework requirements specification for almost a month.

Message for HKCI students
Sun Oct 28 09:29:51 GMT 2007
Dear HKCI students,

I see that you are following MBASE from your discussion. However, you are still not using SQUAD correctly. Most of your messages postings are 'U' for unclassified, when in fact it should have been either 'S' for suggestion' or 'D' for delivery.

Whenever you are making suggestion to the group about the coursework, you must use 'S' in your posting. When you are listing things that has to be done, and who should be doing it, or if you are uploading a file for the group based on what you have been asked to do specifically, it should be 'D' for delivery.

If you are asking a question, and you want members of the group to help you with the answer, then your posting should be of the type 'Q'. Similarly, when you are answering a question, this again should be 'A'. You should rarely use 'U', as this category, within SQUAD does not contribute to 'critical thinking' within online groups.
Cheers
Module Leader

***Figure 3.* Instructions for using the SQUAD environment by the Module Leader**

The students throughout the semester performed the initial coding. This was after it was carefully explained to the students how to use the SQUAD approach to code their online messages within the SQUAD environment. The messages were re-coded at the end of the semester in the form of code-recode.

A semi-structured approach to online discourse such as the SQUAD framework (Oriogun, 2006) is more effective than using inter-rater reliability measurement of online transcripts when using the *Practical Inquiry* (PI) model to assess critical thinking or cognitive presence of online groups. The reason for this is that students would have categorised their own message transcripts according to specific categories given to them from the start of the coding process. Consequently, there should be little or no need for inter-rater reliability when using SQUAD. Figure 4 below shows actual suggestion from one of the students: student S5.

Table 1

Code-Recode of Hong Kong Software Engineering Students' Transcripts (Semester 1, 2007-2008)

Student	CODE (6 OCT 2007-16 JAN 2008)					RECODE (11 FEB 2008)				
	S	Q	U	A	D	S	Q	U	A	D
S1	3	0	9	1	0	3	0	4	2	4
S2	3	0	4	0	0	0	0	4	0	3
S3	4	0	2	1	6	1	0	5	0	7
S4	0	2	6	2	1	3	1	2	1	4
S5	11	1	5	0	1	4	0	1	0	13

Figure 4 shows actual SQUAD message of the type "Suggestion or S" posted by one of our Hong Kong-based students. Figure 5 depicts actual SQUAD message of the type "Delivery or D" sent by one of our London-based students involving the rest of the members of that group. Figure 6 shows an actual SQUAD message of the type "Unclassified or U" which equates to the cognitive presence model's *other.* Finally, Figure 7 shows actual SQUAD category of the type "Question or Q" and the "Answer or A" to the same question by another group member.

This current undertaking of code-recode is to clean the coded transcripts by the students over the semester, by checking that their SQUAD categories were correctly applied to messages sent by each of them throughout the semester. In particular, we are currently trying to understand the phenomenon that students are experiencing when they post messages within the category of "Unclassified-U" or in terms of the cognitive presence model *other*.

Q-(Documentatn), SysCfg should belong to where? - Student S5
Wed Nov 07 06:28:24 GMT 2007
Dear everyone,
Kenny just contact me to tell me that his suggested contents of the system documentation has been confused by us. For example, According to the mBase, "System Configuration" should be a chapter in Development Requirements, but NOT in System and Software Requirements Definition (SSRD). Below is the arguements of the arrangements of the contents. May everyone give some suggestions?
====Version A====
2.3. System interface Requirements 2.3.1 User interface Requirements 2.3.1.1 Graphical User Interface Requirements 2.3.1.2 Command-line Interface Requirements 2.3.1.3 Diagnostics Requirements 2.3.2 Hardware Interface Requirements 2.3.3 Communications Interface Requirements 2.3.4 Other Software Interface Requirements 2.4. Level of Service Requirements
====Version B====
2.3 System Specification 2.4 System Configuration 2.4.1 Hardware Requirements 2.4.2 Tools Requirements 2.4.3 Language Requirements 2.5 System Interface Requirements 2.5.1 User Interface Standards Requirement 2.5.2 Communication Interface Requirement 2.6 Level of Service Requirements
===============
Cheers,
Student S5

Figure 4. **Hong Kong-based students: Actual SQUAD message sent by student S5 labeled "Suggestion-S."**

The course adopted for this empirical study is known locally at London Metropolitan University as CS3021 (Software Engineering 2). The course is of advanced standing and compulsory for students on the BSc Computing degree pathway. The course has been running locally with the University's for a number of years; however, this was the first time the course ran in Hong Kong. The course has two components, namely, group coursework (50%) and unseen examination (50%) at the end of the semester.

The group coursework component was delivered almost totally online with some face-to-face interaction with local tutors of one hour per week. Our London-based students experienced exactly the same treatment in terms of the provision of the SQUAD environments as a means of communication within small group collaborative CMC discourse. Table 2 shows the code-recode of our London based software engineering students' 89 SQUAD message transcripts.

Table 2

Code-Recode of London-Based Software Engineering Students' Transcripts (Semester 1, 2007-2008)

Student	CODE (4 OCT 2007-16 JAN 2008)					RECODE (28 FEB 2008)				
	S	Q	U	A	D	S	Q	U	A	D
S6	4	0	3	0	0	2	2	2	0	1
S7	13	1	1	4	10	14	0	1	4	10
S8	18	1	0	0	1	10	5	1	0	4
S9	18	0	0	0	0	9	1	1	0	7
S10	8	0	0	0	2	10	0	0	0	0
S11	4	1	0	0	0	2	1	1	0	1

D-Documentation available for Peter - Student 7
Fri Jan 11 09:23:48 GMT 2008
OCD- Student S9 with help from Student S11 and Student S6
(prototype)

SSRD- Student S6
SSAD- Student S7
LCP- Student S8
FRD- Student S10

Iteration Plan- Student S11
Release Description- Student S8
Quality Management Plan- Student S9
Test Plan- Student S7
Test Description- Student S7
Partially completed test log- Student S7
Inspection Plan- Student S6
Inspection Report Student S6

New Program- Student S9

What was supposed to be done by Student who left the group
The program
User Manual
Test logs

Figure 5. **London-based student's message: Actual SQUAD message sent by student S7 labeled "Delivery-D."**

Students' coursework was monitored through the SQUAD software prototype throughout the semester. Table 3 depicts the direct mapping of the SQUAD approach to the cognitive presence phases.

Table 3

SQUAD mapping of Cognitive Presence Phases (Oriogun, 2006)

Practical inquiry model's cognitive presence phases (Garrison et al., 2001)	SQUAD mapping of cognitive presence phases (Oriogun, 2006)
Trigger	(S+Q+A) / 2
Exploration	(S+Q) /2
Integration	D / 2
Resolution	(A+D) /2
Other	U

Results

The recoding of Hong Kong students' SQUAD online message transcripts by the author was completed almost three weeks after the students had completed the group coursework. Table 4 shows the Hong Kong software engineering students' practical inquiry model's critical thinking mapping using SQUAD recoded transcripts.

Table 4

Hong Kong-Based Software Engineering Students Practical Inquiry Model's Critical Thinking Mapping Using SQUAD Recoded transcripts

SQUAD practical inquiry model's critical thinking mapping	Student 1	Student 2	Student 3	Student 4	Student 5
Trigger	19%	0%	4%	22.7%	11%
Exploration	12%	0%	4%	18.2%	11%
Integration	15%	21.5%	27%	18.2%	36%
Resolution	23%	21.5%	27%	22.7%	36%
Other	31%	57%	38%	18.2%	6%

The category termed "other" within the Practical Inquiry (PI) model phases still need to be understood by the researcher, as the original authors (Garrison, Anderson, & Archer, 2001) of the PI model admit that they were not sure of exactly what type of phenomena was happening in terms of students' critical thinking.

Meyer (2003) coded this category as "social" when she used the PI model to investigate face-to-face versus threaded discussions and the role of time and higher-order thinking. What Meyer refers to as "social" relates to students agreeing to a prior posting without additional comments and requesting personal information, assistance on a non-course related issue, or comments on issues not related to the topic (Meyer, 2003, p.62).

The category of "other" is therefore not encouraged, as it probably does not add any meaningful value to critical thinking in small group collaborative learning. It is therefore more desirable, within the context of using the Practical Inquiry (PI) cognitive presence

model to validate other content analysis schemes such as the SQUAD approach, to just concentrate on the first four phases of the cognitive presence model, namely *Trigger*, *Exploration*, *Integration*, and *Resolution.*

Clearly, from the recoded message transcripts in Table 4, Student 1 experienced the first four phases of the cognitive presence model (Trigger 19%, Exploration 12%, Integration 15%, and Resolution 23%). However, 31% of this student's posting constitutes "Other." This may be interpreted as a whole, which almost 70% of the postings from Student 1 directly relate to higher-order or critical thinking, whilst around 30% of his postings are irrelevant to critical thinking online.

We can summarise the online message contributions of Student 2 as having only 43% higher-order or critical thinking elements (Integration 21.5% and Resolution 21.5%). More than half of this student's online message contribution deviated from the main topic or subject of the group coursework (other 57%). Furthermore, this student did not post messages under two categories of the cognitive presence model constituting higher-order or critical thinking (Trigger 0% and Exploration 0%).

Student 3 almost mirrored the contributions of Student 2; the only difference is that there was only small evidence that the student was triggering discussion and exploring different possibilities (Trigger 4% and Exploration 4%). The integration and resolution of ideas (Integration 27% and Resolution 27%) was only slightly above the contributions from Student 2 for the same two categories. Once again, a disproportionate number of posting categories as other were encountered (other 38%).

U-comment of the user requirment - Student S2
Mon Oct 22 00:51:36 BST 2007

well done Student S3, you can add more suggediton
or requirement on the system. We can discuss
more the system advantage or how can improve
the system usefully from the user.
GD job. Student S2

Figure 6. **Hong Kong-based student's message: Actual SQUAD message sent by Student S2, labeled "Unclassified-U."**

Student 4 and Student 5 are the students categorised as having experienced higher-order or critical thinking online in the group. It is evident that Student 5 focussed mainly on the task at hand, and only 6% of his postings were categorised as "other." Student 4 contributed almost three times as many message postings (18.2%). In total, almost 82% (Trigger 22.7%, Exploration 18.2%, Integration 18.2%, and Resolution 22.7%) of SQUAD message postings from Student 4 contributed to the four main phases of higher-order critical thinking, whist for Student 5, this figure rose to 94% (Trigger 11%, Exploration 11%, Integration 36%, and Resolution 36%). Table 5 shows our London-based software engineering students' recoded transcripts.

Table 5

London-Based Software Engineering Students Practical Inquiry Model's Critical Thinking Mapping Using SQUAD Recoded Transcripts

SQUAD practical inquiry model's critical thinking mapping	Student 6	Student 7	Student 8	Student 9	Student 10	Student 11
Trigger	28.7%	32%	37.5%	28%	50%	30%
Exploration	28.7%	24%	37.5%	28%	50%	30%
Integration	6.95%	17%	10%	19%	0%	10%
Resolution	6.95%	24%	10%	19%	0%	10%
Other	28.7%	3%	5%	6%	0%	20%

Clearly, from the re-coded message transcripts in Table 5, Student 6 experienced the first four phases of the cognitive presence model (Trigger 28.7%, Exploration 28.7%, Integration 6.95%, and Resolution 6.95%). However, 28.7% of this students posting constitutes "other." This may be interpreted as a whole that almost 71.3% of the postings from Student 6 directly relate to higher-order or critical thinking, whilst around 28.7% of his postings are irrelevant to critical thinking online.

We can summarise the online message contributions of Student 7 as having only 97% higher-order or critical thinking elements (Trigger 32%, Exploration 24%, Integration 17%, and Resolution 24%). Student 8, on the other hand, spent equal amounts of posting triggering discussion and being in explorative state (37.5% each). There was not a lot of integration and resolution categories of SQUAD postings by Student 3 (10% each), and only 5% under the category of "other."

Q-My files - Student S11
Sat Dec 08 12:57:29 GMT 2007
Could anyone tell me if you are able to open any of my files

A-Student S11 - Student S7
Thu Dec 13 12:33:29 GMT 2007
I can open the iteration plan, cant open the SSRD. Try changing the name of the file, it worked for me

Figure 7. **London-based student's message: Actual SQUAD messages sent by student S11 labeled "Question-Q" and Student S7 "Answer-A."**

The number of SQUAD message postings from Student 9 is very similar to that of Student 8; however, Student 9 posted 10% less than Student 8 with respect to the categories Trigger and Exploration, and about 10% more of Integration and Resolution, whilst the type "other" from Student 9 remains at 6%. Student 10 refused to neither integrate nor resolve group problems collaboratively online (0% for both, see Table 5), whilst he posted exactly

the same number of SQUAD messages (50% each) triggering and exploring ideas collaboratively online.

Student 11 devoted an equal amount of time to triggering discussion and exploring ideas about the group coursework online (30% each, see Table 5), whilst only 20% of his postings relate to integrating and resolving problems within the group collaboratively online (10% each, see Table 3). 20% of the SQUAD postings from Student 11 fell under the category of "other."

Table 6 shows the average Practical Inquiry model's SQUAD postings by the two case study groups in our current study.

Table 6

Comparison of Practical Inquiry Model's Critical Thinking SQUAD Postings for Hong Kong- and London-Based Software Engineering Students (Semester I, 2007-2008)

SQUAD practical inquiry model's critical thinking mapping	Average practical inquiry model's SQUAD postings by Hong Kong-based software engineering students	Average practical inquiry model's SQUAD postings by London-based software engineering students
Trigger	11.34%	34.37%
Exploration	9.04%	33.03%
Integration	23.54%	10.49%
Resolution	26.04%	11.66%
Other	30.04%	10.45%

Discussion

In this article, we have empirically tested and validated the SQUAD approach using the Practical Inquiry's cognitive presence model as a framework. When Meyer (2003) used the cognitive presence as a framework, she recommended that the "framework provides some support for the assertion that higher-order thinking can and does occur in online discussions" (p. 55).

In Meyer's (2003) study, she asserts that Garrison, Anderson, and Archer (2001) suggest that *integration* and *resolution* require "time for reflection." This, we believe, implies that in order to increase the number of responses in the integration and resolution categories, it is better for students to operate within the SQUAD framework asynchronously (time delayed) so that students will have time to reflect on what they are conveying to their respective groups collaboratively online.

The direct mapping of the cognitive presence phases to the SQUAD approach's categories will afford students the opportunity to increase their CMC postings under the cognitive presence model's *integration* and *resolution*; consequently, the SQUAD approach is another method of addressing Meyer's concerns that educators may need to be "more directive in their assignments …charging participants to resolve a particular problem, and pressing the group to integrate their ideas or prepare a resolution of the matters under discussion" (Meyer, 2003, p. 64).

In our current study with Hong Kong software engineering students, it is obvious that Student 5 has clearly experienced higher-order thinking or critical thinking as he contributed exactly the same number of SQUAD message postings to the group (36%), whilst spending

about just under a third of his time triggering and exploring ideas with the group (11%). Student 4 is the closest to Student 5 in terms of higher-order or critical thinking online; however, this student contributed exactly the same number of SQUAD message posting to the group in terms of *triggers* and *resolution* (22.7%).

Student 4 also contributed exactly the same number of SQUAD postings to *exploration* and *integration* (18.2%). Unfortunately, Student 4 contributed (up to three times as much as Student 5) SQUAD message postings of the type deemed by Garrison, Anderson, and Archer (2001) as "not [a] cognitive presence" (p.19).

It is very clear that two of the students fully engaged with the SQUAD approach and cognitively engaged with the rest of the group. Two of the group members were perhaps less focussed (Student 2 and Student 3) as they contributed less that 5% of their message posting to Triggers and Exploration phases of the cognitive presence model's phases, choosing instead to devote more postings to the category of "other" (57% and 38% respectively).

Whilst Student 1 is task oriented from his message contributions, almost a third (31%) of his postings did not contribute to phases of critical thinking as proposed by Garrison, Anderson, and Archer (2001) and SQUAD mapping of the cognitive presence phases Oriogun (2006).

With respect to our London-based software engineering students, it is obvious that Students 7, 8, and 9 have clearly experienced higher-order or critical thinking with an average of their posting under the category of "other" being around 4%. Whist Student 6 and Student 11 also experienced higher-order thinking or critical thinking, the proportion of their postings categorised as "other" averaged 24.35%, which indicates that more than a fifth of their contributions were not focussed on the assigned task. Student 10 was happy to explore ideas and trigger discussion without making any effort online to further deepen his learning beyond these two categories.

When we compare the average Practical Inquiry model's SQUAD postings for our Hong Kong- and London-based software engineering students (please see Table 6), we can clearly see that Hong Kong students were more task oriented in that they appear to be task driven, specifically, their average group SQUAD postings under Integration and Resolution is 49.58% (Integration 23.54, Resolution 26.04, see Table 6). Literally half of all their collective postings (approximately 45 SQUAD postings) throughout the semester needed "time to reflect" according to Meyer (2003) when she quoted Garrison, Anderson, and Archer (2001) in her discussion of higher-order thinking with face-to-face threaded discussion.

However, their London-based counterparts for the same two categories averaged 22.15% (approx 12 SQUAD postings), just over a fifth of their overall collective postings. Whilst 20.38% of Hong Kong-based students SQUAD postings were triggering discussion and exploring ideas regarding the group coursework, 67.40% of the SQUAD postings from London-based students (literally two-thirds of their collective postings throughout the semester) fell within these two categories.

This may mean that London-based students had more problems trying to integrate their ideas for the coursework as well as finally resolving aspects of the coursework to be delivered by each student in the group after discussion with the rest of their group member. This was true for the London-based students as two problematic groups regrouped to form a group of six almost half way through the semester.

Although the number of collective SQUAD postings under the category of "other" from our Hong Kong students over the semester averaged 30.04%, they were more focussed as a group compared to their London-based student counterparts, who posted only 10.45% collectively under the same category during the course of the semester.

The limitation of this study is that it is still time consuming to conduct code-recode to detect critical thinking or higher order thinking in the way we have suggested in this article.

The article also assumes that the tutor (instructor, tutor, lecturer, or facilitator) performing the recoding should have full understanding of the original semi-structured coding protocol, such that he or she will be able to perform the exercise as an expert on this type of content analysis protocol.

This again, is subjective; however, we believe that this subjectivity is not so high as to hinder the detection of critical thinking or higher-order thinking using this particular content analysis protocol.

Conclusions

This empirical study using the SQUAD direct mapping of the practical inquiry's cognitive presence model phases gives an indication that critical thinking or higher-order thinking certainly exists within online collaborative learning environment where knowledge emerges and is shared.

Our Hong Kong students were more tasks driven with appropriate reflection; the London-based students did not demonstrate these attributes to the same degree. We have carefully mapped the SQUAD approach directly to the cognitive presence model such that message categories under Integration and Resolution will always increase. This, we believe, should hopefully reduce the number of postings categorised as "other."

The empirical work described in this article shows that it is time consuming to conduct content analysis of online transcripts, especially when using inter-rater reliability measure. It is better to devise a semi-structure approach to online discourse whereby students can choose a limited set of alternatives themselves instead of tutors developing coding categories upon which to code student's messages.

Code-recode in form expressed in this article will help CMC transcript analysis researchers to further clean or validate semi-structured transcripts when using the cognitive presence model as a framework for their own research context.

We believe that the theoretical and empirical work described in this paper supports our assertion that critical thinking or higher-order thinking can be measured by the SQUAD approach using the cognitive presence model (Garrison, Anderson, & Archer, 2001) as a framework. The case study presented, involving final year undergraduate students from London Metropolitan University, is a way of further empirically validating the critical thinking of the SQUAD approach to online discourse within groups.

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