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An Empirical Study of Knowledge Creation and Interaction in Argumentation Setting

ChingMiin Duh

LiarnRurng Wen

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ChingMiin Duh
MIS Department
YungTA Institute of Technology and Commerce
PingTung, Taiwan
duh@mail.ytit.edu.tw

LiarnRurng Wen
MIS Department
Meiho Institute of Technology
PingTung, Taiwan
Wen@mail.meiho.edu.tw

Abstract

The paper defines Computer-Supported Collaborative Argumentation as a collaborative activity supported by CMC, which focuses on argumentation interactions. CSCA embeds the advantage to eliminate social context cues and provides a direct channel to express one's opinions. In this case, Computer-Supported Collaborative Argumentation (CSCA) becomes a new paradigm supported by Computer-Mediated Communication. CMC facilitates a context for participants within argumentation interactions that embed the advantages of computer conferencing. The goal of our research is to analyse the relationship between knowledge creation and quality of interaction and quality of discussion within an argumentation process. We report data of an experiment in which 120 MIS 2nd years students use four communication media settings on knowledge creation. The results suggest that an argumentation-based approach provides an environment not only for creating but also for motivating a community-wide view of information sharing because it enables discussion, mutual engagement and autonomy of knowledge exchanging. Also, in contradiction to media richness theory, this study indicates that structured argumentation-based software results in a better quality of argumentation interaction within the team, and more favourable attitude and participation in interaction, and thus yields the highest level of knowledge creation among four different communication configurations (including face-to-face).

Keywords: Argumentation, Knowledge creation, CSCA, Toulmin, SECI

1. Introduction

This empirical study reports the considerations which have to be taken into account in order to understand the relationship between knowledge creation and communication configurations. Recently, Computer-Supported Collaborative Argumentation (CSCA) becomes a new paradigm of virtual learning and knowledge creation. CSCA is supported by Computer-Mediated Communication (CMC), since CMC facilitates a context for participants within argumentation interactions; in this case, CSCA embeds the advantages of computer conferencing. There are many studies focus on knowledge management but not many detail in knowledge creation neither the influential factors of knowledge creation. Nonaka and Takeuchi [10] state that there are four types of knowledge transformation , in order to achieve the successful outcome of four types of knowledge transformation, participants have to participate in collaborative activity enthusiastically. Due to CSCA embeds the advantage to eliminate social context cues and provides a direct channel to express one's opinions. From knowledge creation aspect, it is possible to infer that because the individual externalises his/her existing knowledge and internalises different opinions and comments from argumentation stimuli, the processes trigger knowledge transformation and knowledge creation. This research attempts to verify in general to understand the relative effects of four communication configurations : face-to-face, email and automated argumentation facilitator software and self study., and in particular the relationship between knowledge creation and argumentation.

2. Development of Research Model

Epstein [7] argues that in knowledge sharing, communication skills are more relevant than types of knowledge. In this context, the channels of communication may dominate the processes of knowledge sharing; they may influence knowledge transformation and knowledge creation. In order to

investigate issues relevant to argumentation-based knowledge transformation, the present research seeks answers to the following questions:

1. How does a collaborative argumentation-based setting help or hinder knowledge processing?
2. How does Computer Supported Collaborative Argumentation System (CSCA) help or hinder knowledge processing?
3. Is the CSCA model effective for creating knowledge?
4. How can an Automatic Argumentation Facilitator (AAF) in CSCA model help or hinder knowledge transformation?
5. How effective is the support provided by the Automatic Argumentation Facilitator
6. What is the relationship between knowledge transformation types and knowledge creation?
7. Which type of knowledge transformation has the most impact on knowledge creation?

We identify *subject knowledge*, *argumentation interaction quality, knowledge interaction quality, motivation and participation, problem solving ability*, and *knowledge transformation types* as the dependent variables. With the characteristics of these variables, we explore the influence of this combination of variables within numbers of combinations of different interaction models, different communication treatments and different argumentation structures. Therefore, we identify *interaction model (argumentation vs. without argumentation), Communication treatment (Traditional vs. CSCA),* and *argumentation structure (structured vs. unstructured)* as independent variables. Damon [5] states that it is important to know the impact of interaction settings on the individuals. In the present study we look into the effectiveness of different combinations of independent variables as well as the effectiveness within different combinations of independent variables. The former focuses on social, meta-cognitive and the outcome results, for example, subject knowledge and problem solving ability. The latter emphasises the interactions in the processes such as knowledge interactions quality, argumentation interaction quality, and the transitions between different knowledge types. We chose a pre-test/post-test design in order to know how altering the combination of variables changes the outcomes.

However, researchers suggest that when we try to obtain deep understandings of information technology and its uses it is not sufficient just to focus on outcomes; we must also study the processes and interactions within the research [4][5][11]. This study selects quantitative approaches to analyse and categorise unstructured arguments (Email) and structured arguments (F2F and AAF) within the processes.

In Figure 1 we illustrate the experimental configuration, **Self-study** indicates a configuration without argumentation setting; **Email** indicates an unstructured computer-supported collaborative

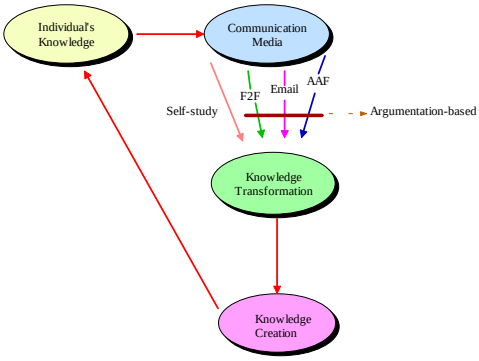

Figure 1. Research Model

argumentation configuration; on the other hand, **AAF** indicates a structured computer-supported collaborative argumentation configuration (automated argumentation facilitator software); and **F2F** (face-to-face) indicates a structured conventional collaborative argumentation configuration. In this experiment we use "structured" to suggest that argumentation interaction applies Toulmin's model, that is, the participants have to issue their claims followed by the data and the warrant.

According to Media-Richness Theory (MRT), task performance can be improved when task information processing requirements are matched with a medium's ability to convey information richness (Daft and Lengel, 1984). Face-to-face is considered as the richest medium; it has great potential for carrying information (e.g. emotional, attitudinal, and normative), and is recommended for resolution of an equivocal situation (e.g. negotiation). A lean medium (e.g. a text-base or memo is always used to exchange unequivocal messages

Based on McGrath and Hollingshead [8], a CSCA system can be considered a moderate media richness medium between text-base and face-to-face. It is the best fit to intellective tasks. In this study groups are designed to work in different settings: Self-study, F2F, Email and the AAF system. The principal research framework and relationships from the literatures is shown in Figure 1. The correlation between dependent variables and independent variables is depicted in Figure 2.

3. Hypotheses

Computer-Supported Collaborative Argumentation (CSCA) is an avenue for achieving conditions for knowledge creation. For example, because of the advantages of reducing the social anxiety of CMC, individuals may experience less apprehension and may be more willing to share their experience (tacit knowledge). Once individuals are willing to share their knowledge source, collected intelligence is fulfilled. We claim that CSCA facilitates the process of eliciting the knowledge, elaborating the knowledge, amplifying the knowledge and justifying the knowledge. We use this concept to investigate the hypothesis that collaborative argumentation is an approach to the improvement of knowledge transformation; an automatic argumentation

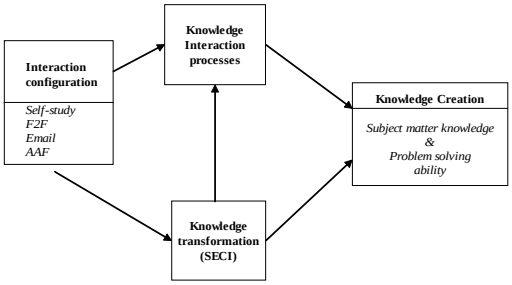

Figure 2. Correlation between dependent and independent variables

facilitator (AAF) in computer-supported collaborative argumentation (CSCA) facilitates a better result of knowledge transformation; the differences in communication configuration influence the type of knowledge transformation, thus affecting knowledge creation.

In order to investigate how different configurations affect subject matter knowledge, three hypotheses were established and tested.

Hypothesis 1: Participants in an argumentation-based process acquire more subject matter knowledge compared to the participants without an argumentation-based setting.

Hypothesis 2: Participants in a CSCA model acquire more subject matter knowledge compared to the participants in a traditional argumentation-based setting.

Hypothesis 3: Participants in a structured CSCA argumentation environment acquire more subject matter knowledge compared to the participants in an unstructured CSCA environment.

One of the potential advantages of CMC is that it allows the application of a spectrum of structured and unstructured techniques and methods to perform a task. We designed two CMC communication configurations in our experiment: the Email setting and the AAF system. The main difference between the AAF system and the Email system is that the Email system is an unstructured argumentation environment; individuals can articulate their opinions and arguments in a text-based format without any style limitation. On the other hand, the AAF system is a structured argumentation context, which provides graphic representation of arguments. Whilst individuals externalise their arguments they have to follow Toulmin's argumentation model. There are a number of advantages of the AAF system setting over the Email setting. Firstly, the AAF system facilitates an argumentation structure. It fosters an environment to direct participants through a sequence which aims to reach consensus. Secondly, the AAF acts as a neutral third party or referee. It provides support for group dynamics, such as maintaining the agenda of argumentation. Moreover, according to certain rules or algorithms, the AAF system manages the conflict and evaluates the strengths of the arguments. Further, the AAF system can limit the amount of non task-related talk hence it improves argumentation efficiency. Finally, with synchronous WYSIWIS feature, the AAF system presents the arguments in graph structure to both parties spontaneously, it stimulates participants creating as a result a high quality of knowledge interactions. With these advantages we establish the following hypotheses to justify our investigation.

Hypothesis 4: Participants in a structured CSCA argumentation environment have a better quality of argumentation interaction compared to the participants in an unstructured CSCA argumentation environment.

Hypothesis 5: Participants in a structured argumentation environment have a better quality of knowledge interaction compared to the participants in an unstructured argumentation environment.

Hypothesis 6: Participants in a structured argumentation environment have a better perception and higher participation compared to the participants in an unstructured argumentation environment.

Based on the elimination of non task-related talk and the prescribed sequence of process, Hypothesis 7 examines the problem-solving ability in different argumentation-based settings.

Hypothesis 7: Participants in a structured CSCA argumentation environment acquire more problem-solving ability compared to the participants in an unstructured CSCA argumentation environment.

4. Methodology

Subjects. The participants in the experiment were 120 2nd year students at the university majoring in management who enrolled on the course in Management Information Systems. The experiment is incorporated into a four weeks workshop which delivers the topic related to the Groupware concept, the participants are required to attend the workshop once a week. The participants are told that the subject knowledge in the workshop will be included in the final examination, and the performance in the workshop is also counted as a partial credit of the final mark. Two groups of 60 students are formed: the treatment group in which, in the argumentation-based model, members are asked to elaborate their arguments within the experiment; and the control group that relies solely on self-study. The group in the argumentation-based setting is further divided into three sessions; each session has 20 students who participate in different settings. According to this design there are four sessions in the experiment: (1) session one neither computer-supported nor argumentation-based model (self-study), (2) session two is an argumentation-based model with traditional F2F (face-to-face) interaction, (3) session three is an unstructured CSCA environment (Email), and (4) session four is a structured CSCA environment (AAF).

Experimental Task. The participants in the argumentation-based sessions were asked to perform a collaborative problem solving and decision-making task. It involves ranking 15 desert survival items in a simulation of a desert survival situation [9][2]. We used "The lost kingdom of the Sahara" as the title of the experiment. The desert survival simulation describes a group of four archaeologists who encountered the challenge to rank 15 salvaged desert survival items in the desolate region of the Sahara in the middle of summer (where their plane has crashed). To further understanding, the experiment provides a URL containing the scenario of the task, desert survival knowledge from desert survival experts, and useful dynamic web links, which are relevant to the workshop.

Moreover, the Web page also includes details of the experiment and instructions on how to use the AAF system. The reasons to choose such a task are because (1) the task is open-ended problem solving, (2) the task is "light" to every participant without much "heavy" knowledge, (3) the task embeds an interesting competitive game which can provoke argumentation, (4) the task stimulates participants to search for more information in order to support their arguments, (5) the task requires higher-order skill (analysis, evaluation, synthesis) and deep elaboration, and (6) the task facilitates collaborative learning and collaborative argumentation.

Many studies [6][3][1] show that collaborative problem solving is one of the most effective paradigms to promote learning. We hypothesise that the task has the advantages of provoking argumentation, supporting critical thinking and exploring multiple perspectives which trigger knowledge transformation and enhance knowledge creation.

Procedure. The total experimental duration is five weeks; the first meeting takes place before the workshop begins. In the first meeting participants are introduced to the concept of CMC and Groupware as well as the schedule of the experiment and desert survival simulation. A form, which includes a list of 15 desert survival items, is distributed to the participants, and participants are asked to rank the order of survival items within 35 minutes. The forms are collected at the end of the meeting and marked according to the "experts' ranks". Participants are required to practice the materials on the Web page, which is designed for the desert survival situation simulation workshop. The Web page contains the details of the experiment, CMC and Groupware concepts, desert survival knowledge, Toulmin's model and the instructions of how to use the AAF system.

We conclude this section with the summary of research procedure:

Step 1. Provide desert survival kits ranking form to all the participants.
Step 2. Participants rank the survival kits and return the form to the instructor.
Step 3. The form is marked according to "experts' ranks".
Step 4. Introduce Groupware concept, Toulmin's model and the AAF system.
Step 5. Participants access the Web page to practice using the materials which are relevant to the desert survival situation simulation workshop.
Step 6. Tutoring session for the AAF system and Toulmin's model.
Step 7. Participants engage in experiment under different communication configuration.
Step 8. Participants complete problem-solving ability ranking form according to their communication configuration.
Step 9. Participants fill the post-experimental questionnaire individually.
Step 10. Data collection and analysis.

Data Collection. The primary methods of data collection in the present study are; post-experimental questionnaire; problem-solving ability test (desert-survival items ranking); and transcripts of argumentation. The main reason for these methods is because the major part of the study is concerned with the perception of the different communication configuration in argumentation, interaction within the argumentation, and how these perceptions and interactions affect knowledge transformation and further knowledge creation. Pre-test of problem-solving ability can provide the sketch of an individual's desert survival ability. For the argumentation-based/self-study group, post-experimental questionnaire measures desert survival knowledge, perception of the activity and the interaction within argumentation. Post-test of problem-solving ability assesses the desert survival ability after experiment on a team basis (argumentation-based) or individually (self-study), it presents the strength of collaborative argumentation in different communication configuration.

5. Findings

In this study, the participants collaboratively generate the knowledge for problem solving, and then apply the knowledge which they explore from interaction; the score of problem-solving ability is the representation of knowledge application. Of the 120 university students majoring in MIS as study participants, most participants completed their post-experimental questionnaire; but more than half of participants in argumentation-based setting were unable to complete their whole discussion of desert-survival items ranking because of time constraints. However, final valid data in this study is 62: 36 from Self-study group, 8 from face-to-face group (dyads), 10 from the Email group (5 dyads), and 8 from the AAF setting. The data are used to test ten research hypotheses.

The study explores knowledge processing in argumentation-based setting; furthermore, the study investigates the influences of the automatic argumentation facilitator in knowledge transformation and knowledge

creation. From data analyses, we summarise the findings related to each research hypothesis.

Hypothesis 1. We had hypothesized that an argumentation-based setting would be positively associated with subject knowledge gain, but the result shows no support for our hypothesis. The participants in Self-study have a higher mean of subject knowledge compared to the participants in a face-to-face and the Email system and this implies that collaborative argumentation does not guarantee better subject knowledge as a result. Many factors have to be considered in the activity. For example, communication medium selection, time arrangement, dyads arrangement and task characteristics. The fact that the AAF system facilitates diagrammatical argumentation features in the process could be a factor explaining the highest subject knowledge gain.

Hypothesis 2. With information technology, it is reasonable to hypothesise that the participants in the CSCA model gain higher subject knowledge compared to the participants in the traditional model. The data analysis supports our expectation. We found that the participants in the face-to-face setting perceive some degree of social contextual cues, this may affect the motivation in argumentation activity.

Hypothesis 3. As Hypothesis 1, we expect that with computer supported well formatted and well structured process design, participants may acquire more subject knowledge, since the AAF system can provide suitable features to facilitate the argumentation process. The result supports our hypothesis but the result is not significant.

Hypothesis 4. In a structured CSCA environment, participants experience higher motivation and comfort when they use the AAF application, on the other hand, the participants in an unstructured CSCA environment may perceive it to be laborious and cumbersome thus decreasing the quality of argumentation interaction. The data supports our hypothesis but the result is not significant.

Hypothesis 5. Quality of knowledge interaction is one of the important variables in the knowledge process; we hypothesized that the participants in a structured argumentation environment should have better quality of knowledge interaction. The data analysis does not support our expectation. We infer that the relationship between argumentation moves and the communication medium is an important factor; the participants in a structured argumentation environment may perceive constraints while they express their thoughts. For example, in the AAF system, the participants have to follow Toulmin's model to articulate their arguments and in a face-to-face setting, participants perceive some degree of socially contextual cues while they present their opinions.

Hypothesis 6. In a structured argumentation environment, participants may perceive effectiveness of learning in argumentation, and thus may provoke motivation in the activity. The data analysis support this hypothesis but there is no significant result.

Hypothesis 7. The relationship between problem-solving ability and structured/unstructured CSCA settings is supported and is statistically significant. The data analysis yields an interesting finding that a good quality of argumentation interaction may promise the better outcome of problem-solving ability in negotiation types of task. Even the participants in the Email system have a good quality of knowledge interaction, but they acquire the lowest problem-solving ability score, and this may imply that engaging in argumentation does not necessarily result in good problem-solving.

6. Conclusions

We compared the means of subject knowledge, quality of argumentation interaction, quality of knowledge interaction, and the perception and participation between a structured argumentation-based software environment and a traditional argumentation-based environment. We found that the participants in the structured argumentation-based software environment have higher subject knowledge gain, higher quality of knowledge interaction, and higher perception and participation but lower quality of argumentation interaction compared to the participants in the traditional face-to-face argumentation environment. The data reveal that with the advantages of information technology participants experience easy articulation of their arguments and this increase in terms of subject knowledge. The results of this study indicates that the participants in a face-to-face interaction have the highest score of problem-solving ability, and participants in self-study have the second highest score of problem-solving ability.

The task for participants in this study is an open-ended problem-solving task; it can be categorized as a negotiation conflict-of-interest task , and therefore, the face-to-face communication model is the best fit to the task (according to Hollingshad *et al*., [8]. The results support media-richness theory (MRT) which suggests that if task information processing requirements are matched with a medium's ability to convey information richness then this can improve task performance.

7. References

[1] Baker, M. 1992. Modelling negotiation in intelligent teaching dialogue. In M. ElsomCook & R. Moyse (Eds.), *Knowledge negotiation*, 199-240. London: Paul Chapman Publishing.

[2] Balthazard, P.A. 1999. Desert Survival Situation-Internet Edition. Available at http://consensus.west.asu.edu/dss115.

[3] Burnett, R. E. 1993. Decision-making during the collaborative planning of co-authors. In A. Penrose & B. Sitko (Eds.), *Hearing ourselves think: Cognitive research in the college writing classroom*. 125-126. NY: Oxford University Press.

[4] DeSanctis, G. and Poole, M.S. 1994. Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory. *Organization Science.* Vol. 5, No 2, 121-147.

[5] Damon, W. 1991. Problems of direction in socially shared cognition. In L. B. Resnick, J. M. Levine, & S. D. Teasley. *Perspectives on socially shared cognition*. 384-397. Washington: APA.

[6] Erkens, G. 1997. *Co-operative problem solving with computers in education: Modelling of co-operative dialogues for the design of intelligent educational systems*. Utrecht, The Netherlands: Brouwer Uithof.

[7] Epstein, L. D., 2000. Sharing Knowledge in Organization: How people use media to communicate. *Unpublished doctoral dissertation, University of California, Berkeley*.

[8] Hollingshead, A. B. McGrath J. E., O'connor, K. M. 1993. Group task performance and communication technology: a longitudinal study of computer-mediated versus face-to-face work groups. *Small Group Research*, 24 (3), 1993, 307-333.

[9] Human Synergistics, 1987. *Desert Survival Situation*. Plymouth, MI: Human Synergistics.

[10] Nonaka, I., and Takeuchi H., 1995. *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. NY: Oxford University Press.

[11] Nunamaker, J., Dennis, A., Valacich, J., Vogel, D., and George, J. 1991. Group Support Systems to Support Group Work. *Communications of the ACM*, Vol. 34, No 7, 40-61.