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# SYNCHRONOUS COLLABORATIVE CONCEPT MAPPING VIA ICT: LEARNING EFFECTIVNESS AND PERSONAL AND INTERPERSONAL AWARENESS

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**Abstract**. This study investigated both learning effectiveness and personal and interpersonal awareness in synchronous collaborative problem-solving concept mapping (CM) via ICT with two computer communication channels. Sixty students in 30 groups drew their shared concept maps in three conditions of the experiment, face-to-face (FtF), ICT with text, and ICT with audio and text connection. In interpersonal awareness, participants in the audio/text group had lower performance in attention and total score in comparison with FtF group and lower performance in reaction with both text and FtF groups. In learning effectiveness, there were no significant differences amongst the groups, but in learning effectiveness at the level of the group as a whole the performance of the text group was better than both FtF and audio/text groups. The results show that CM in collaborative learning situation via ICT can be used as effective as FtF and more research is needed to show the reason of lower performance of the text/audio group.

## 1 Introduction

Over recent decades, learning and teaching have not been immune from the general trend towards use of information and communications technology (ICT). In fact, education has traditionally accepted some forms of new technology easily, such as the interactive white board. But in spite of the widespread usage of technology in education, the role of technology has not been considered as central to learning and teaching processes until recently. This is because technology was not able to support some critical aspects of educational activities, such as collaborative learning and face-to-face interaction, and could not replace other facilities within the classroom. With the emergence of ICT, consideration has been given more to use of this technology to confront with these challenges both in relation to the content and methods of learning and teaching. With the opportunities afforded by ICT, the possibility of addressing these requirements on educational system is close to being realised. Obviously in this area, one of the challenges is finding ways and methods that learning effectiveness can be promoted in leaning and teaching via ICT. In this regard, one solution is the application of mind tools, like CM, in learning and teaching via ICT. But in view of the differences between traditional and electronic methods, more research is needed to explore the optimal facilities and methods for using the mind tools in learning. This study gives consideration to use of CM as one of the most effective mind tools, and collaborative learning as one of the most widespread learning strategies, in learning via ICT.

## 2 Mind Tools and Concept Mapping

Mind tools are one of the effective applications of technology in education. They have derived from learning and educational theories to promote learning and teaching. Jonassen describes mind tools, or cognitive learning tools, as “computer-based tools that facilitate generative process of information by learners” (1992, P. 3) and “facilitate critical thinking and higher-order learning” (1999, P.152). Mind tools include a wide range of technologies from databases, spreadsheets, and semantic networks to multimedia construction tools and expert systems. Research results have shown that the use of mind tools can promote the process of learning. Therefore, the application of mind tools can be a desirable addition to many educational activities requiring deep engagement with learning materials. One of the most useful mind tools, with a strong theoretical and research background, is CM which belongs to a category of computer tools that were designed specially for learning (Jonassen, 1992).

Novak began to study and develop the CM technique in the 1960s. Although researchers have presented many definitions for CM, most of them are common in their application of a few key words: *node* (concept, point, vertices), *link* (line, arc), *proposition*, and *graphical* or *visual representation*. Reader and Hammond (1994) suggested a simple definition for concept map as " a graphical representation of domain material generated by the learner in which nodes are used to represent domain key concepts, and links between them denote the relationship between these concepts" (P. 52). According to Anderson (2000), a proposition is the smallest linguistic unit that carries meaning. The effectiveness of CM has been shown by many research studies in various fields and so researchers and educators in a wide range of sciences have used it (e.g. Stoddart, Abrams, Gasper, & Canaday, 2000). Generally, ways that CM can be effective may be summarised as below: a way of representing knowledge and measuring it, an activity that promotes learning of certain sorts of knowledge, and a tool for measuring changes in knowledge.

### *2.1 Concept Mapping with Technology*

Four different steps can be recognised in technology use in CM. In the first step, CM was carried out using paper and pencil, requiring a lot of time and effort both from students, for creating and revising, and from teachers, for evaluating the CMs. This emphasis on process may have resulted in less attention being given to the knowledge itself (Chang, Sung, & Chen, 2001). The second step began with expansion of personal computers. Using software developed for creating CMs, students and teachers could construct, modify, maintain, and analyse CMs more easily. This step was developed further with the advancement of multimedia, allowing the use of sounds, video and pictures in concept mapping. The third step extended the use of CM within hypertext and hypermedia, with an emphasis on its role in learning and teaching (Hammond, 1993). For example, Reader (1994) worked on CM tools with hypertext and suggested that constrained knowledge structuring tools may provide a useful for aiding the process of learning. Finally, the development of the Web resulted in developments and research into the use of CM within web-based environments (e.g., Tsai, Lin, & Yuan, 2001). The current focus of research is on the web-based CM with synchronous and asynchronous communicative facilities (e.g., Cañas et al., 2001). Collaborative CM has therefore become feasible even when participants are distributed. The trend towards web-based CM systems provides opportunities for the application of concept mapping within electronic learning environments, like VLEs.

## 3 Collaborative Concept Mapping

One of the most promising uses of CM is its integration into co-operative learning activities. In this situation the members of a group collaboratively construct group maps. It supports discussion about concepts between members of a group.

Computers and ICT have been used to support collaborative CM since the mid-1990s (e.g. Cañas et al., 2001) and some moves to create web-based tools with collaborative facilities have taken place (e.g., Luckie, Batzli, & Ebert-May, 2002). Gaines and Shaw (1995) carried out one of the first attempts to use CM for collaboration on the Web. However, their work focused more on the technical aspects of the collaborative CM on the web and was not concerned with the learning and teaching situation. Cañas et al., (1995) used a "knowledge soup" as a collaborative software system. This was a store of students' concepts and links they had used for their concept map. All users could see them without seeing the whole of other students' CMs. The research showed with collaborative effort students could elaborate, refine, and improve their own knowledge structures. The authors believed more research was needed to improve the methods for using collaborative concept mapping as a tool for representing knowledge (Cañas et al., 2001).

The application of CM as a collaborative tool has been used both in educational and business setting and both in FtF and at distance learning, either synchronous or asynchronous (Cañas et al., 2004). Although some research suggest that collaborative CM is an effective tool that can lead to effective discussions concerning concepts and thus enhance meaningful learning (e.g., Fischer, Bruhn, Grasel, & Mandl, 2002), others have shown that collaborative CM is not effective (e.g., Chung, O'Neil, & Herl, 1999). It causes more research to tackle this incompatibility and more focus on the process of collaboration in collaborative CM. For example, Chiu, Huang, and Chang (2000) investigated the interaction patterns among participants to explore how participants use the communication process to accomplish a synchronous web-based CM task. They found that greater interaction with the complex co-operative tasks led to better performance in a group. Boxtel, Linden, and Kanselaar (2000) studied the influence of task characteristics on the elaboration of conceptual knowledge in social interaction. They compared CM with a poster task and investigated the effect of individual preparation in learning. They found CM had a significant effect on discussion about concepts, collaboratively elaborated conflicts and reasoning, but no higher individual learning outcomes. Stoyanova and Kommers (2001) investigated the learning effectiveness of CM for computer-supported collaborative problem-solving. They showed that shared cognition, when all members of a group collaboratively construct a map, is more effective than moderated and distributed collaboration.

In summary, the idea of CM has been recognized for nearly two decades and several computer-based tools are now available. Some attempts are now being made to design web-based CM systems for synchronous collaborative CM. The web-based CM software can provide an opportunity for applying this technique in online and electronic learning environments. Although some research has been done into collaborative CM, most studies were used asynchronous conditions or synchronous FtF collaboration with technology. Thus, with increasing consideration being given to electronic learning, and with the development of web-based CM systems, research is needed to investigate the various aspects of synchronous collaborative CM techniques, both regarding collaborative learning and instruction. This study is the first of a set that investigates some of the issues in this area. It was an exploratory one involving the implementations of a learning system that makes use of synchronous web-based CM to encourage higher-level thinking using collaborative learning structures via ICT. Two specific issues of this study relate to the communication channels used and to the comparison of learning effectiveness of collaborative CM either FtF or via ICT. Thus, two questions are addressed in this study: (1) is collaborative synchronous, web-based, CM as effective as collaborative CM using FtF? (2) What CMC channels are needed to improve collaboration in synchronous CM via ICT?

## 4 Method

### *4.1 Design and Participants*

This study used a between-subject design. The between-group variable was the kind of computer-mediated communication channels in collaborative web-based problem solving CM task with three levels: online with written chat (text) versus online with audio/text connection versus face-to-face (FtF).

Thirty pairs of participants from York University (12 males and 48 females; age 17 to 23 with mean of 19.2 years) volunteered to take part in the experiment. Twenty participants, ten pairs, served in each condition. There were no significant differences among the conditions regarding the participants’ age, average working with computer per day, computer and CM knowledge and experience, working with yahoo messenger, and working in collaborative learning situations ($P < .05$). 47 participants were native (British). The gender and nationality composition of participants in collaborative conditions was controlled, with nearly the same numbers of each possible gender pairing and nationality in each condition. The degree of friendship between participants was controlled: each participant had to bring a friend as a partner.

### *4.2 Pilot Study*

A pilot study was conducted to choose a suitable collaborative problem-solving CM task, and to evaluate the experimental instructions and procedure and use of the software. For choosing a suitable task, a group of postgraduate students suggested some possible topics by brainstorming and the two most suitable tasks were chosen for the pilot study. Eighteen participants, two pair groups in each condition (FtF and ICT) and each task (termed *planning a university campus* and *graffiti*), answered to two questionnaires. In the first questionnaire, they assessed the tasks on collaborative criteria, including motivating, interesting, CM usability, concept diversity, collaboration, and controversy. In the second questionnaire, participants assessed the instructions and the software of the experiments. The results showed participants believed the university campus task had better capability for using in a collaborative problem-solving CM situation. In addition, on the basis of the results, some parts of the research protocol and the instructions were amended.

### *4.3 Material*

IHMC CmapTools beta version 3.0 (dsp) was used for CM. This software allows users to collaborate on making a CM. With the collaborative part of the software, users can immediately see changes made by their partner on a shared CM and communicate via a chat room. For CMC channels, Yahoo Messenger version 5.0 was used in the collaborative groups. Experimental sessions took place in controlled experimental rooms equipped for remote communication. Each room had a PC with all necessary equipment. A set of written instructions were provided. Participants completed four types of questionnaires. The first, completed before the experiment; measured their previous abilities, experiences, and knowledge of computer, CM and collaborative learning. The other questionnaires were filled out after the collaboration session by participants who served in collaborative groups. The technology questionnaire measured the participants' evaluation of the technology, CmapTools and Yahoo Messenger software. The third questionnaire assessed participants' awareness in communication, based on a questionnaire developed by Monk and Watts (1998), and with two sections, interpersonal and personal awareness. In the original questionnaire, the first section consisted of 12 items that asked participants how aware they were of their partner with six measures (presence, reactions, attention, contribution, understanding, and addressing). As the experimental groups were dyads, two questions regarding addressing were omitted. The second section consisted of ten items related to personal awareness (engagement, involvement, role, attention, and interest). The questions regarding the role were omitted because were not related to the task. Each measure of the questionnaire had one positive and one negative item. There was also an open-ended question in which participants could write any comments they had about the task. In fourth questionnaire participants reported their assessment about who led the collaborative session in terms of the constructing the map and contributing knowledge and ideas for constructing the map. In all questionnaires, the participants gave their answers on a 100mm analogue Likert-type scale.

### *4.4 Procedure*

Participants initially filled out the personal detail questionnaire, were provided with written instructions and a short training session place. In this session, the experimenter drew a sample concept map with Cmap and answered any questions related to the experiment and the software. Then participants had 15 minutes to draw an individual concept map. The task was a scenario about the planning of a new university campus. After this step, participants were divided randomly into the three conditions of the experiment. In condition one, participants used CmapTools software to make a CM with FtF collaboration. They worked together on the previous task. In the second and third conditions, participants were given the same task but in separate rooms. For collaboration, they used the online collaborative part of CmapTools but with different CMC channels. In the second condition, participants used the written chat room of Yahoo Messenger whilst those in the third used both the written and audio connection of Yahoo Messenger. Participants, in all conditions, had a maximum of 40 minutes to draw a shared CM but could finish earlier if they felt their map was complete. At the end of this session, participants filled out the technology and awareness questionnaires.

### *4.5 Scoring System of Concept Maps*

Whilst CM technique has been accepted in many fields, assessing a CM has remained a controversial issue. A proposed taxonomy for analysis levels of learning effectiveness in collaborative CM is developed in Khamesan & Hammond, 2004. On the basis of Stonayova's and Kommers's initial work (2002), learning effectiveness is divided to three levels, the level of individual learning, the level of the group as a whole, and the level of interaction between individual and group. For each level, a number of sublevels are proposed that can be used as a basis for analysis of learning effectiveness in collaborative CM and other collaborative task. Table 1 presents definitions of levels and their sublevels. The taxonomy includes provision for a post-test session, not included in the current study.

### *4.6 Reliability of Scoring System and Questionnaires*

The reliability of the awareness questionnaires were calculated using Chronbach’s Alpha. The questionnaires show high reliability, with r =.87 for interpersonal awareness, r =.67 for personal awareness and r = .81 for the whole of questionnaire. The reliability of the scoring system was calculated by inter-rater reliability. Three raters marked 30% of CMs (48 CMs). The correlation among the raters’ scores were high on nearly all measures (between r =.52 for and r= 1), indicating good reliability of the scoring system.

## 5 Results

A brief summary of the result of the experiment is presented in three sections: using technology, CMC channels, and learning effectiveness. The mean for each scale was analysed, with a score between 0 and 100, where a high score on the question represents a high level of agreement with the question.

**1. Learning effectiveness at the individual level:**

1.1 ***Individual Achievement:*** Total number of concepts in post-test. It includes sublevels of enrichment and retention. (*)

1.2 ***Enrichment:*** Difference between post-test and pre-test. It includes: (**)

1.2.1 **Knowledge Acquisition**: New concepts in post-test. It includes concepts transferred from the group CM and new individual concepts.

*1.2.1.1* ***Individual Creativity****:* New concepts that were neither in pre-test nor in group CM.

1.3 ***Retention****:* Concepts are transferred from pre-test to post-test.

1.4 ***Structure & Configuration****:* Distribution of concepts in different levels in relation to central concept. (**)

**2. Learning effectiveness at the level of the group, as a whole:**

*2.1* ***Group Achievement****:* Total number of concepts in group CM. (*)

*2.2* ***Structure & Configuration****:* Distribution of concepts in different levels in relation to central concept in group CM. (**)

*2.3* ***Group Creativity****:* New ideas and concepts, in group CM, that are not in pre-tests and are created only in collaboration session.

**3. Learning effectiveness as an interaction between individual and group achievement**

3.1 ***Individual-to-Group Transfer****:* Concepts are transferred from pre-test to group CM.

*3.2* **G*roup-to-Individual Transfer*** *(Retention in group level):* Concepts are transferred from group CM to post-test. (*)

3.3 ***Individual-to-Individual Transfer****:* Concepts are transferred from one of peer's pre-test to his or her partner's post-test. (***)

3.4 ***Rejection at Group Level****:* Concepts of pre-test that are not transferred to group CM. (***)

3.5 ***Rejection at Individual Level****:* Concepts of group CM that are not transferred to individual post-test. (***)

3.6 ***Overlapping****:* Overlapping of individual CMs, both between individual pre-tests and individual post-tests. (***)

*Note:* Asterisks at the end of each sublevels show type of amendment from Stoyanova and Kommers's work (2002): (*) indicates only change of name, (**) indicates change of definition or re-categorisation, and (***) indicates new sublevels.

**Table 1:** Levels of learning effectiveness analysis

### *5.1 Using Technology*

The means, standard deviations, and the results of ANOVA of participants' assessment of the technology, Cmap and Yahoo Messenger, used in the experiment have been presented in table 2. The results show participants in both FtF and ICT groups agreed on the positive performance of CmapTools both in individual and in collaborative concept mapping and used the software without any major problem. Participants in ICT groups assessed use of Yahoo Messenger positively. There were no significant differences between groups regarding agreement on technology used in the experiment (P>.05).

| **Questions** | **Conditions** | | | | | |
|---|---|---|---|---|---|---|
| | FtF | Text | Text/Audio | F | df | P |
| 1) Perfect performance of Cmap in individual concept mapping | 71(20) | 81(12) | 80(12) | 2.68 | 38 | .08 |
| 2) Perfect performance of Cmap in collaborative concept mapping | 78(13) | 74(16) | 67(23) | 2.18 | 38 | .12 |
| 3) Working without problem with Cmap in collaborative concept mapping | 70(25) | 75(14) | 7423) | .36 | 38 | .73 |
| 4) Perfect performance of Yahoo Messenger | | 87(10) | 86(13) | | | |
| 5) Working without problem with Yahoo Messenger | | 84(15) | 84(20) | | | |

**Table 2:** Means (and standard deviations) of participants' agreement on technology used for concept mapping and collaboration

### *5.2 Awareness in Collaboration*

The awareness questionnaire had two sections, *interpersonal awareness* (or awareness of others), with five measures (attention, presence, reaction, understanding, and contribution), and *personal awareness* (awareness of self), measuring impressions of enjoyment, involvement, attention, and interest. The results of the awareness questionnaire are presented in figure 1 (personal) and figure 2 (interpersonal).

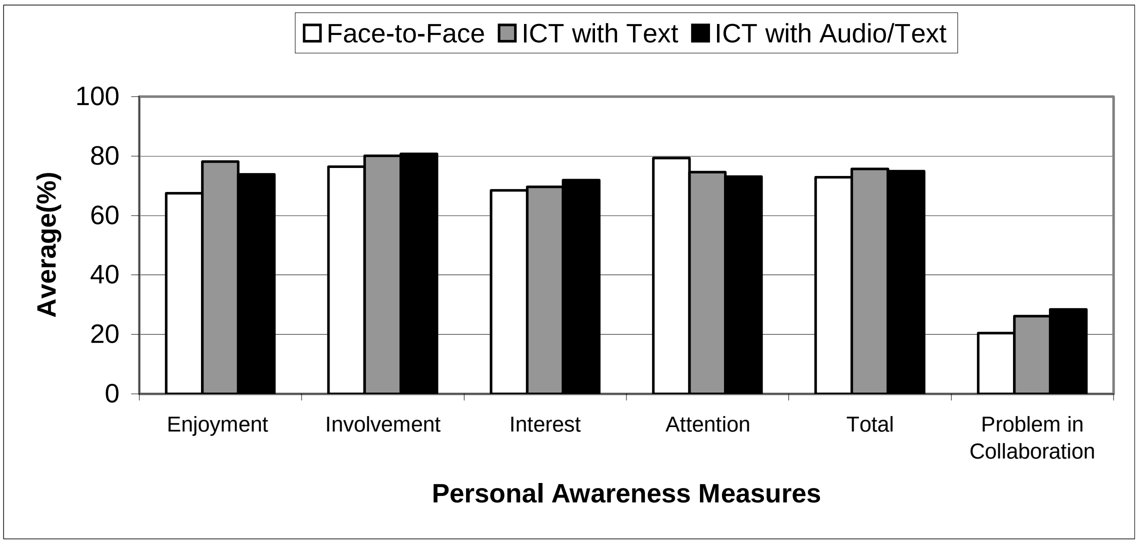


**Figure 1:** Personal awareness measures

For personal awareness, there were no significant differences between mean scores for each condition. The participants in ICT groups had slightly higher personal awareness for three of the four measures. The final group on the graph (*problems in collaboration*) presents results from a question regarding the problems that the participants had in collaboration. The differences were not significant although the FtF group reported slightly fewer problems than the two ICT groups.

For interpersonal awareness, analyses of variance revealed statistically significant differences amongst the groups in measures of attention (F= 6.81, df=59, P=.002) and reaction (F= 9.25, df= 2,59, P.000), and in the total interpersonal awareness score (F= 6.32, df= 2.59, P=.004). Tukey HSD tests showed that the FtF group had significantly higher scores than the audio/text group in attention and total interpersonal awareness (P> .01). For the reaction measure, the audio/text scores are significantly lower than the scores for both the other two groups (*vs* FtF, P=.000; *vs* text, P= .034).

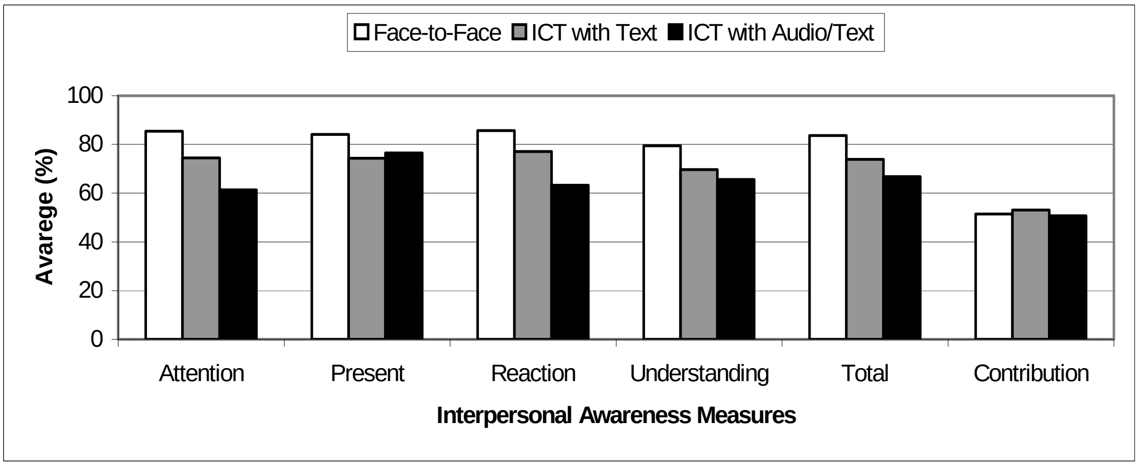


**Figure 2:** Interpersonal awareness measures

### *5.3 Learning Effectiveness*

Each participant constructed an individual CM in the pre-test phase and a shared concept map with his or her partner in the collaborative session, with a total of 90 CMs constructed. The scoring of the individual CMs show that there were no significant differences among groups in any of measures relating to base level, structure and configuration of CMs (P>.05).

Learning effectiveness was measured in two ways. The first was in terms of the shared CMs using three measures: *group achievement* (number of concepts), *structure and configuration* (reflecting map structure) and *group creativity* (new concepts not present in either individual CM). The second was in terms of the interaction between shared and individual CMs, with two measures of *transfer* (number of concepts in shared CMs also present in the individual CMs) and *rejection* (number of concepts in individual CMs not included in the shared CM).

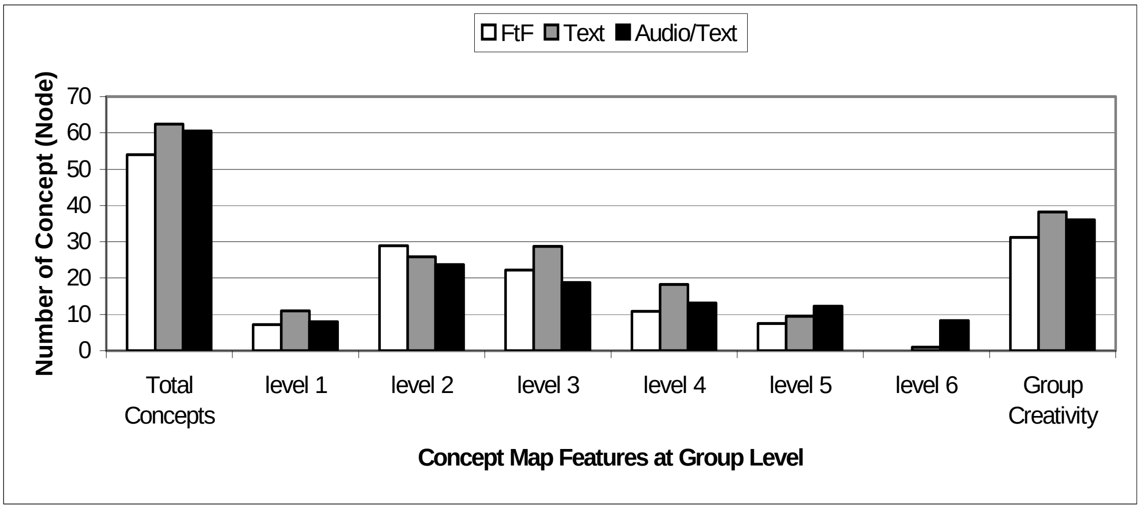


**Figure 3:** Learning effectiveness at the group level

The results of learning effectiveness at the group level are presented figure 3 which show total concepts and concepts at each hierarchical level. Analysis of variance showed no significant differences between the groups, although numerically the text group generated more concepts than the other two groups. The results of learning effectiveness at the interaction level are presented table 4. There were no significant differences between the groups in transfer and rejection rates.

| Measures | Conditions | | |
|---|---|---|---|
| | FtF | Text | Text/Audio |
| Individual to group transfer | 26(9) | 21(11) | 24(7) |
| Rejection at the group level | 26(20) | 22(13) | 22(8) |

**Table 4:** Means (and standard deviations) of learning effectiveness measures at the level of interaction between individual and group

## 6 Summary

The result shows that computer-based concept mapping can be use in collaborative learning with remote communication as effectively as with face-to-face communication, although more research is needed to clarify issues how performance is mediated by different CMC modes. Participants using audio/text communication showed lower levels of interpersonal awareness (on measure of attention and total score) in comparison with the FtF group, and lower performance in the reaction measure compared to both other groups. This effect was unexpected insofar as the text only group would be expected to have the lowest communication bandwidth. The finding might be in part caused by the higher loading of the computers in audio/text conditions causing some degradation of communication speed: this possibility is under further investigation. However the finding does suggest that where network performance is not of high quality, using typed communication for collaborative CM might be just as effective as audio communication.

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