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Is Relevance Relevant? Investigating Coherence in Knowledge Sharing Environments

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ABSTRACT

This paper focuses on the impact of relevant backgrounds on computer-mediated knowledge sharing and individual knowledge acquisition. An experiment is described based on the coherence principle from the Cognitive Theory of Multi-Media Learning. Results suggest groups using visual chat scored higher in retention and understanding than individuals working alone. In addition, participants using visual chat with relevant backgrounds obtained higher levels of understanding than participants using no relevance or irrelevant backgrounds. These results support the coherence principle in the cognitive theory of multimedia learning and suggest new directions in the design and evaluation of knowledge sharing environments.

Keywords

Knowledge sharing, collaborative learning, computer mediated communication, knowledge acquisition.

INTRODUCTION

Advances in information technology (IT), including synchronous person-to-person communication, widen choices for business communication (Smith et. al., 2003). Companies are using IT to facilitate knowledge sharing by supporting activities such as electronic meetings, international team development, and electronic forums (Brazelton and Gorry, 2003; Chai et. al, 2003). While collaborative systems exist, a positive link between collaborative technology and knowledge sharing has not been established (Kock and Davison, 2003). This has led to a call for research in this area: "To what degree does the application of IT to knowledge transfer increase the knowledge transferred among individuals" (Alavi and Leidner, 2001, p. 139).

This paper focuses on two questions related to this discussion: 1) do group members supported by collaborative technology acquire more knowledge than individuals without the opportunity for collaboration, and 2) does the collaborative environment make a difference in the level of knowledge acquired? Much depends on how the technology can be used to aid individual knowledge acquisition. The track record of application designers has been weak (Landauer, 1995). Norman (1990) suggests the overriding issue may be technology-centered design as opposed to a user-centered approach. Mayer (2001) supports this suggestion and notes we are in early stages in understanding how to use technology effectively.

Purpose Statement

This paper presents results from an experiment manipulating the design of a human-computer interface to evaluate the effectiveness of a collaborative knowledge sharing environment. Focus is placed on one element of the environment: the background. The coherence principle from the cognitive theory of multimedia learning (Mayer 2001) is used to hypothesize that a background in a computer mediated collaborative environment containing relevant information will lead to a higher level of individual understanding than a background with either no relevant or irrelevant information. The dependent variable is the level of understanding as developed by a group member. An experiment with a control group and three treatments is described. Results from this experiment support the coherence principle and provide two results: 1) that distributed groups can be more effective in knowledge sharing than working individually and 2) that the environment for knowledge sharing can make a difference in the level of understanding.

BACKGROUND

Knowledge sharing is defined here as a process of communicating explicit representations of knowledge (diagrams, documents, e-mails) among a group with the purpose of fostering understanding. A literature review revealed an array of studies and perspectives. In considering our focus on computer-mediated environments to support knowledge sharing, three issues were apparent 1) how individuals acquire knowledge, 2) how this knowledge acquisition might be supported collaboratively, and finally 3) how this collaboration might be supported by technology. Frameworks considered from each of these areas are summarized in Table 1 below.

The research areas described above might initially suggest disparate perspectives on knowledge sharing. On deeper inspection, however, the models share much common ground. The disparity is more the result of a different focus than different perspectives on knowledge transfer. For example, if we assume the "task dimension" in the Dennis et. al (1988) GSS model is knowledge sharing, then all three models suggest sharing knowledge is a process, with potentially measurable outputs. The difference between the models is in the inputs recognized in the process. The Alavi and Leidner (2001) knowledge transfer model recognizes different knowledge types (explicit, tacit) and group memory (semantic and episodic) as relevant inputs. The knowledge acquisition model (Mayer, 1989) would view group memory as residing within "individual characteristics". The knowledge types would be considered "content" which is represented to individuals using various "presentation methods" (verbal, visual or multimedia). In turn, these presentation methods can be viewed as functions supported by the "technology" dimension of the Dennis et. al. (1988) GSS model. The GSS mode recognizes the influence of organization and context explicitly, but this is also recognized by Alavi and Leidner (2001) who state the important influence of the organization in the knowledge sharing process when they note: "*This view of organizations as knowledge systems represents both the cognitive and social nature of organizational knowledge and its embodiment in the individual cognition and practices as well as the collective (i.e. organizational) practices and cultures*" Alavi and Leidner (2001, p. 115).

Research Area	Primary Refer.	Analysis Focus	Inputs Recognized
Individual Knowledge Acquisition	Mayer (1989)	Individual	Content Presentation Method Individual Characteristics
Knowledge Transfer	Alavi and Leidner (2001)	Individual/ Group	Knowledge types Group Memory
Computer Mediated Group Support (GSS)	Dennis et. al (1988)	Group	Group Task Context Technology

Table 1. Summary of Background Research

Assumptions

Our consideration of literature supporting knowledge sharing environments suggests a process model and sets of inputs to consider in knowledge sharing. These models do not provide, however, a theory explaining how knowledge acquisition might occur. Before introducing theory we make three assumptions guiding our choices in theory development. The first assumption is that knowledge is a justified belief (Nonaka, 1994). In taking this approach we accept the constructivist approach (Chai et. al., 2003) and choose to separate knowledge held within individuals from information represented and stored externally. The implication is that knowledge can only be held within individuals and suggests the output of knowledge sharing can be measured at an individual level.

The second assumption follows from the constructivist view and recognizes that knowledge presented is not necessarily equal to knowledge gained. Developing knowledge requires individuals to actively engage in selecting, organizing and integrating presented information. Two persons presented with the same material may develop different levels of knowledge depending on what information they paid attention to and how it was integrated into memory.

The final assumption is to suggest that groups can be viewed as perceptions of other individuals. While groups have been studied at both the group and individual level, we assume a "group" as viewed from one member's perspective can be different from the same "group" viewed for a different member's perspective. It is our view that perceptions of the group and of the people within the group can be assessed at an individual level.

These assumptions enable us to focus attention on the individual. We will view information presented to the individual as content, in one presentation format or another, and recognize that individuals can differ in the level of knowledge attained from the viewing the same content. These assumptions provide the basis for suggesting a theory of knowledge sharing focused at the individual level. We therefore suggest the Cognitive Theory of Multimedia Learning (CTML), introduced by Mayer (2001), as a useful theory for understanding knowledge sharing in computer mediated collaborative environments.

COGNITIVE THEORY OF MULTIMEDIA LEARNING

The CTML has been developed through more than a decade of empirical work using a variety of experimental data (Mayer, 1989; 2001). This foundation has been used to compare presentations in science learning (Mayer and Gallini, 1990), multimedia explanations (Lim and Benbasat, 2002) and conceptual modeling in systems analysis (Bodart et. al, 2001).

The theory focuses on the interaction between a learner and presented information. It argues for two pathways in cognition, verbal and visual. While independent, these channels can interact in working memory. When a person views presented material, relevant sensory information is selected through the verbal and visual channels into working memory. This information is organized into visual and verbal models. Linkages between these models can be created in working memory. These two models are then integrated with prior knowledge to develop new understanding. An overview of the theory is provided in Figure 1.

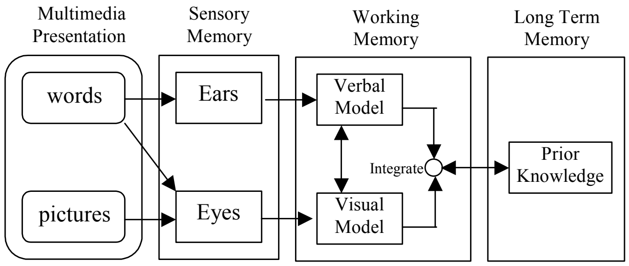


Figure 1. Overview of CTML (Mayer , 2001)

Assuming dual channels exist, it can be argued that not all presentation formats are equally successful in producing learning outcomes. For example, providing a written passage while simultaneously narrating the passage will not be an effective presentation format because both of the presentation methods are utilizing the verbal channel. Since cognitive resources are limited, using the same channel creates a capacity conflict resulting in only a portion of the information reaching the learner. In addition, the ability to create linkages between verbal and visual models is lost as no visual information is provided.

Learning Outcomes

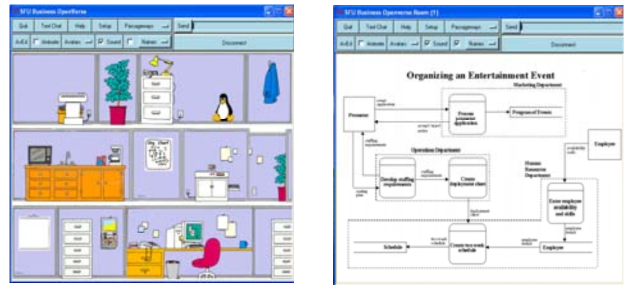
Mayer (2001) suggests three outcomes when presenting material: 1) no learning, 2) rote learning and 3) meaningful learning. These outcomes are based on measures of two variables: retention and transfer. Retention is the comprehension of material being presented. Transfer is the ability to use acquired knowledge to solve new but related problems. For example, if presented with an explanation of how a car's braking system works, a retention question might be "What are the components of a braking system," but a transfer problem might be "How can you make a car stop faster?"

Regarding learning outcomes, no learning occurs when retention and transfer are low. Rote learning occurs when retention is high and transfer measures are low. Meaningful learning occurs when both retention and transfer are high. The high transfer score indicates a high level of understanding of the material

HYPOTHESES

An experiment was developed to test the CTML in a distributed knowledge sharing environment. We focused on a system analysis and design task; specifically, the interpretation of a system analysis diagram. This task is appropriate because: 1) it is an explanative task containing explicit knowledge, 2) it combines pictures and words, 3) it not simple to understand, and 4) it is often accomplished in groups supported by technology.

The technology used to support this task was a synchronous visual chat using peer-to-peer technology to emulate distributed group discussions (Smith et al, 2003). Visual chat is a type of chat where group discussions occur in a "room" often with the use of avatars (small icons representing a participant) and an ability to move in the discussion room. Two examples of the chat rooms used in the experiment are provided in Figure 2.



Cartoon Room **DFD Room**

Figure 2. Visual Chat Rooms used in Experiment

Three treatment groups and a control group were compared. The control group worked individually with no support from technology. The first treatment group (plain room) was provided with a visual chat environment featuring a white background. The second treatment (cartoon room) was provided a chat environment with an irrelevant cartoon background The third treatment (DFD room) was provided a background with a relevant dataflow diagram embedded into it.

In a study of collaborative technology, Alavi (1994) argued that a group support system "enhances the effectiveness of collaborative learning … by increasing group process gains and decreasing group process losses.' (p 163). Recognized process gains included more information being generated, potential for synergies, group motivation and more effective evaluation of information. Based on a body of research in collaborative learning, a specific hypothesis was formulated:

> H1: The control group, who work alone, will score lower in both retention and transfer than the treatment groups (who work in groups).

The Coherence Principle

The background may add to the chat experience, however, it can also distract. The coherence principle, derived from the CTML, suggests that uninformative and irrelevant information distracts from the potential for understanding and reduces the coherence of the message. Irrelevant information must be filtered. This filtering uses valuable cognitive resources, providing less for knowledge development. If irrelevant information is selected into working memory, cognitive effort is wasted on integrating unrelated words and images. The coherence principle, along with the definition of meaningful learning, enables us to develop our second hypothesis:

> H2: A Visual chat environment with a relevant background will produce higher learning outcomes (higher transfer scores) than visual chat environments with either irrelevant or not relevant backgrounds.

METHOD

Participants included 101 undergraduate students in management information systems familiar with dataflow diagramming. The experiment took place in a computing lab with 30 stations. Twenty-nine participants served as a control group. They worked alone (no groups) with exactly the same materials as other treatments. Remaining participants were randomly assigned to a group with 3, or if necessary, 4 members. Each group was then randomly assigned to one of three treatments. An average of 15 people and 5 different groups worked simultaneously in each session.

Group members were spread throughout the lab to eliminate face-to-face discussion. Participants started with a pretest. Next was a short introduction to the chat tool, OpenVerse (www.openverse.com), which was used in the experiment. OpenVerse is an open source application that runs on variety of platforms and provides the ability to embed GIF (Graphics Image Format) files into the background, a function required for this experiment. To familiarize group members with the group and the chat tool application, participants were then asked to use OpenVerse to select a group name. To increase task participation, a monetary incentive was provided to the group with the most creative name in each session.

After completing the group naming exercise, participants were asked to answer the multiple-choice questions in Part I using OpenVerse as a discussion forum. In Part II, participants were asked to turn off the computer monitors and answer questions individually. Participants were given 2.5 minutes to answer each transfer question.

The only difference between treatment groups was the background image used. The first treatment group used a plain white background for chatting. The second treatment group used a cartoon as an irrelevant background (Figure 2), and the third treatment group used the relevant Data Flow Diagram (Figure 2). In addition to the background, each participant was also provided with an "avatar" and a text chat toolbar to view the discussion.

Paper-based materials included a pretest survey, a case description, the DFD diagram and two tasks. The pretest gathered participants' demographics and experience regarding computer skills, discussion tools and Data Flow Diagrams. In Part I, a one page written case with an accompanying DFD was given to each participant. Along with 12 yes/no/uncertain questions These questions familiarized participants with the diagram and measured the level of retention. In Part II, the chat discussion was stopped and case materials and computing resources were taken away. Participants then answered four open-ended transfer questions. These questions were used to measure the level of transfer, which is a measure of the understanding developed from viewing the case materials (Mayer, 2001).

RESULTS

Two ANOVA analyses were performed on the data, one for each dependent measure. The means and standard deviations of the dependent measures (retention and transfer) across the three treatment groups are provided in Table 2. The F statistic and p-value results of the ANOVA tests for each dependent variable are provided in the final column of Table 3. A post hoc analysis using least square differences (LSD) are provided in Table 3 to show comparisons across treatment groups.

Measure	Treatment Groups				
	Control Group n=29 Means (SD)	Plain Room n=21 Means (SD)	Cartoo Room n=27 Means (SD)	DFD Room n=24 Means (SD)	Sig. n=101 F Stat (p-val)
Retention	8.07 (1.44)	9.10 (.54)	9.22 (.42)	8.79 (.41)	9.83*** (0.000)
Transfer	9.00 (1.89)	10.43 (2.36)	10.04 (3.38)	11.92 (2.67)	5.47** (0.004)

** significant at the .01 level, *** significant at the .001 level

Table 2. Means, Std. Dev. And ANOVA Results

Dependent Variable	(I) Treat	(J) Treatment	Mean Difference (I-J)	Std. Error	p-value
Retention	Control Group	Plain Room	-1.03	0.25	0.000***
		Cartoon	-1.15	0.23	0.000***
		DFD Room	-0.72	0.24	0.003**
	DFD Room	Control	0.72	0.24	0.003**
		Plain Room	-0.30	0.26	0.242
		Cartoon	-0.43	0.24	0.079
Transfer	Control Group	Plain Room	-1.43	0.75	0.061
		Cartoon	-1.04	0.70	0.144
		DFD Room	-2.92	0.73	0.000***
	DFD Room	Control	2.92	0.73	0.000***
		Plain Room	1.49	0.79	0.061
		Cartoon	1.88	0.74	0.012*

* significant at the .05 level, ** at the .01 level, *** at the .001 level

Table 3: Post Hoc Comparisons (Least Square Difference)

In the post hoc comparisons, retention scores showed significant differences between control group and the three treatment groups. This results supports hypothesis H1 and suggests the level of retention was significantly lower in the control group (operating individually) than in the treatment groups (operating as groups). Furthermore, no significant differences were found between the three treatment groups in regards to retention. Since the same materials were used in all treatments, the results suggest treatments provided relatively similar levels of content. In other words, regardless of which treatment was provided, individuals were able to generate similar retention scores.

Transfer measures showed differences in the anticipated direction. In post hoc comparison between treatment groups, group members in the DFD room scored higher on transfer than any of the treatment groups, and significantly higher than the control group and "cartoon" room participants. These results suggest that although the retention scores across treatments were the same, the added coherence provided by embedding the DFD into the chat tool enabled participants to develop a higher level of understanding. This result suggests a relevant background can have measurable positive effects on viewer understanding. Chat tools may be an exciting step forward in collaborative knowledge sharing, however the performance of group members can be affected by features in the environment. Careful thought should therefore be placed on delivering environments that are effective and engaging.

CONCLUSION

This experiment has provided two interesting results. The results suggest collaboration in a computer mediated collaborative environment can be more effective than working alone. Additionally, the environment in which groups work matters. Groups working with the relevant information in the background developed a mental model that was facilitated by coherence. This suggests the potential to improve the design of distributed group interfaces to improve knowledge sharing within organizations. Relevant backgrounds are preferable to the plain white or "interesting" backgrounds currently provided by most visual chat environments.

The results also provide support for the Cognitive Theory of Multimedia Learning and the design principles for multimedia messages that the theory suggests. The results suggest the coherence principle is of direct relevance to both the users and designers of visual chat environments and reaffirm the importance of diagrams and visual information in knowledge sharing.

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