The Efficacy Of Online Cooperative Learning Systems The Perspective Of Task-Technology Fit

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Design/methodology/approach – In total, 156 subjects, divided into 46 groups, were invited to resolve decision and intellective tasks in text messaging and audio conferencing e-learning environments.
Findings – For decision-making tasks, audio conferencing has a significant impact on cooperative learning satisfaction but not on learning performance; while for intellective tasks, neither audio conferencing nor text messaging has an impact on cooperative learning outcomes. There are no cross-effects between platforms and task types on cooperative learning outcomes. The results indicate that the main effects of platforms and task types are independent. In other words, the impact of platforms on group discussion processes can be examined without the need of considering task types, since the latter will not affect the impacts of platforms.
Research limitations/implications – The main effects of information richness and task types are independent. Major limitation is that the student sample may not be sufficiently representative to allow wider generalization of the findings of this study.
Practical implications – The main effects of information richness and task types are independent as far as learning outcomes are concerned. The learners' attitude toward the synchronous learning system significantly affects the satisfaction of synchronous online cooperative learning.
Originality/value – This study uses empirical data to validate the hypothesized relationships between the independent variables of online synchronous learning systems (audio- and text-based), the moderating variable of task types (decision making vs intellective) and the dependent variable of learning outcomes.

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The efficacy of online cooperative learning systems

The perspective of task-technology fit

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Keywords E-learning, Decision making, Communication, Learning methods

Paper type Research paper

Introduction

Electronic learning (e-learning) provides the potential for a more differentiated, integrated, and open learning experience. E-learning systems have helped achieve this possibility by radically reducing the need for the trade-off between richness and reach from the perspective of information economics (Evans and Wurster, 1999). The availability of rich information objects, knowledge repository, and the directory of domain experts all considerably affect the creation of new knowledge and innovative ideas. E-learning systems further untangle the geographical limitations of the traditional face-to-face (F2F) learning and, therefore, increase the number and diversity of participants.

Many e-learning systems can help foster an innovative learning environment. An instructor can use asynchronous learning systems, such as discussion forums and online quizzes, to facilitate group discussion and self-evaluation, respectively. Text messaging and video-conferencing are useful online synchronous learning systems for instructors and students to meet virtually. To understand how these systems can foster an innovative learning environment, it is imperative to explore their relationships with learning performance. We argue that although it is feasible to increase information richness via adopting online synchronous learning systems, its ability to promote interpersonal skills, critical thinking, and cognitive learning processes via virtual group discussion is uncertain. This study aims to critically examine the conventional thinking that high information richness is beneficial to cooperative learning by understanding the potential impact of information richness of e-learning systems and cooperative learning tasks on group learning performance.

In addition, there has been much research in the literature on the use of information and communications technology (ICT) to support group processes (Fjermestad and Hiltz, 2001) and to enhance learning (Alavi and Leidner, 2001). However, most laboratory and field studies have focused on the use of specialized groupware, web applications, and video conferencing, and there has not been much research that actually examines the modality of voice. Voice/audio has the advantages of small delay and relatively high information richness, and little work has been done in the last few years on the use of audio in cooperative learning. With the increasing adoption of voice-over-internet protocol (VoIP) on desktop computers, it is likely that voice capability will be built into a majority of desktop personal computers in the near future, and it is important that the community starts to re-examine the use of real-time voice in e-learning, especially when compared with the popular e-learning technology of synchronous messaging. Furthermore, this study responds to the call by Sharda *et al.* (2004, p. 54) to answer the question of "which IT tools offer the most impact in terms of improving learning processes and outcomes?" by investigating the efficacy of audio as compared with the popular modality of text messaging.

Literature review

Although specific definitions of e-learning abound, e-learning is generally defined as "Education and training delivered electronically using ICT". Hence, e-learning systems are those artifacts of ICT that are dedicated to delivering Education and Training. E-learning systems have been implemented using video conferencing, web portals and applications, and information repository and can offer increasing opportunities for online conferencing and collaboration (Harasim, 1993). Universities and corporations alike are increasingly using e-learning systems to broaden the reach of Education and Training delivery (Beck *et al.*, 2004).

In the last ten years, there has been much interest in cooperative and distance learning (Leidner and Sirkka, 1995) via e-learning systems. These interests primarily stem from the recognition that critical thinking and collaboration entail the most valuable form of education that cannot be attained by a student studying alone in an isolated environment away from his or her instructor and classmates (Sherry, 1996). Interaction and more communication are needed. One prominent track pursued by researchers is applying group support systems (GSS) to cooperative learning (Khalifa and Kwok, 1999). A GSS can be defined as a computer-based system that is used to support collective problem solving and group work (Ahituv *et al.*, 1994). GSS has been shown to increase idea generation and exchange. One reason for such increase is that GSS enables parallel processing by decreasing the effects of production blocking, which occurs when someone cannot express his or her idea because another member of the group is talking (Leidner and Fuller, 1997). More recent work in this area has focused on the effect of GSS on knowledge acquisition and knowledge processing (Kwok and Khalifa, 1998; Kwok *et al.*, 2002).

Although GSS has been adopted in e-learning applications, GSS and e-learning systems are two technologies designed for different purposes. This study investigates two synchronous technologies used to support e-learning: audio conferencing and text messaging because while synchronous text messaging has been used by many GSS and groupware applications, audio conferencing has not. In addition, audio conferencing cannot decrease the effects of production blocking the way GSS can because only one person can talk at a time on the conference bridge. Therefore, due to the specific e-learning technologies examined by this study, we adopt the concept of information richness to characterize the technologies in constructing the research model.

Theoretical foundations

Building up the social goods (e.g. rationality and reciprocity) (Turner, 1991), establishing trust and creating norms (Coleman, 1988) are important cornerstones for the success of a virtual community. Having only a semester-long time period to manage a discussion forum for a particular online course may be insufficient to cultivate trust and altruism in the e-learning community. While social exchange does occur in the virtual learning environment (Kim, 2000), instructors and individual students feel less obligated to engage in the process. A myriad of e-learning programs are incorporating high interactive and exciting rich media to enhance cooperative learning. However, information richness elements such as positive or negative physical expressions (e.g. tones, facial expressions, and body languages) which act as effective enforcements in the learning process are lost in the e-learning environment. We argue that although it is feasible to increase information richness via adopting online synchronous learning systems, the effectiveness to promote interpersonal skills, critical thinking, and cognitive learning processes via virtual group discussion is uncertain. A pedagogical interpretation of how we can use online synchronous learning systems to improve effectiveness for cooperative tasks is imperative.

Information richness of e-learning systems

Critical to the effectiveness of an online synchronous learning system is the promotion of the virtual social interaction. Text messaging, animation, audio- and video-conferencing are a few examples of ways to deliver the virtual social interaction synchronously. It is unclear if enhancing the information richness of e-learning systems can correspondingly promote the virtual social interaction, thereby contributing to the efficacy of cooperative learning.

Information richness is "the ability of information to change understanding within a time interval" (Daft and Lengel, 1984, 1986). The richness of an e-learning medium should not be treated as "an invariant, objective property of the medium itself" (Lee, 1994, p. 145). The richness varies in different contexts from the hermeneutic perspective. In the context of e-learning for group performance, e-mail, considered a "lean medium" by the information richness theory, could become a "rich medium" if used properly (El-Shinnawy and Markus, 1997), providing another possible interpretation of the richness of e-learning systems. The conduits of information richness closely related to the context of e-learning include feedbacks, clues, content formats, personalization, and interactivity.

Intellective vs decision-making tasks

McGrath and Altman (1996) assert that differences in group performance can be explained better by taking into consideration the "task" and "group" simultaneously. McGrath (1984, p. 53) recommends that tasks be analyzed "in ways that relate meaningfully to how groups perform them." An e-learning system is an alternative vehicle to facilitate communication and decision making within a group and between groups. This study attempts to investigate the potential impact of task typology on the group performance via e-learning systems.

Task typology has salient effects on cooperative learning processes and performance in the literature of GSS (Ellis and Fisher, 1994). GSS have been assimilated to increase the participation rate of group discussion (Fjermestad *et al.*, 1995). However, there is no evidence to show that e-learning systems would have a similar effect on the participation rate. Nor is it certain that e-learning can contribute to the quality of cooperative learning performance. E-learning systems may inadvertently introduce unproductive factors, such as the loss of information richness, into cooperative learning.

The choice of e-learning systems needs to match the learning objective. When learning objectives are ambiguous and complicated, systems delivering rich information could be superior to those delivering lean information. On the other hand, when learning objectives are clear-cut, systems delivering lean information could be superior to those delivering rich information (Trevino *et al.*, 1990). Learning objectives can be achieved by having learners solve different tasks. To resolve group-based tasks, it is important to know the differences between task typologies and assess the efficacy of e-learning systems with different degrees of information richness.

McGrath (1984) defined solving problems with a correct answer as "intellective tasks" and those with a preferred answer as "decision-making tasks." Decision-making tasks require students to process information and to structure information processes. In contrast, in solving an intellective task, a correct solution is essential. Intangible and ambiguous solutions such as end-user satisfaction, social interaction, and individual preference that are acceptable in the decision-making tasks are intolerable for intellective tasks. A quantifiable solution is the best-fit model for intellective tasks. The majority of the GSS literature asserts that the validity of a research question depends heavily on the task selection and congruence. This study establishes the validity of these assertions by examining the moderating effects of intellective versus decision tasks on cooperative learning performance in online synchronous learning environments.

Team-based e-learning

Just as social interdependence between citizens is necessary for a society, the social interdependence between students and instructors is important to the success of a virtual learning community. Johnson and Johnson (1994) classified three types of learning based on the degree of social interdependences: individual, competitive, and cooperative learning. Social interdependence does not exist for individual learning. The "curving" is a class policy to encourage the *zero-sum* competitive learning, which concurs to a reactive social interdependence. Cooperative learning asserts that students team up to achieve a common learning goal. A single team member cannot succeed in a group assignment unless all team members succeed. The relationship between team members concurs to a proactive social interdependence.

This study investigates how to enhance cooperative learning via an e-learning system. When working as a team, learners are exposed to similar and/or divergent views of team members. Similar views are reinforcements for the existing mental models. Divergent views can challenge a learner's mental model and extend metacognition (Glacer and Bassok, 1989), thereby extending the existing mental models. Either view can lead to cognitive and motivational gains (Brown and Palincsar, 1982), as well as social support and encouragement for individual team members (Alavi, 1994). Positive attitudes can also trigger a higher level of cognitive gains.

In the online synchronous learning environment, team members meet virtually via text-messaging, audio-conferencing and video-conferencing, exchanging messages on a real-time basis. The choice of a particular online synchronous learning medium is the result of a learner's objectively rational process (Fulk, 1993). The choice of systems can also be the product of complex social interactions from the emergent (Contractor and Eisenberg, 1990) and network (Markus and Robey, 1988) perspectives. As such, the properties of e-learning systems could vary from one learner to another. A learner may have a higher perceived value for text-messaging, while another for video-conferencing.

Cooperative learning outcomes

E-learning can be superior to the traditional F2F learning in terms of quantity and quality of interaction by providing personalized and timely feedback with a proper course design (Horn, 1994; Hirumi and Bermudez, 1996). Four kinds of interactions are important in order to create a successful cooperative learning experience in the e-learning environment: student-content interaction, learner-instructor interaction, learner-learner interaction (Moore, 1989), and learner-interface interaction (Hillman *et al.*, 1994). E-learning systems can be used to facilitate these interactions, thereby influencing the participation rate of learners (McHenry and Bozik, 1997).

Another e-learning outcome is learning satisfaction, which is a feeling or attitude towards learning activity. A learner has a high learning satisfaction when the learning activity satisfies and meets his or her learning needs and expectation (Tough, 1982). In a pleasant experience with a high level of learning satisfaction, a student is more likely to prefer group discussion, which helps establish a proactive learning attitude between students. Discussants participate in group discussion based on their personal abilities, needs, and preferences. The personalized learning experience is one key to the learning satisfaction of group discussion (Douglah, 1970). Hiltz (1993) modified Doll and Torkzadeh's (1988) end-user computing satisfaction instrument and proposed a survey to measure the satisfaction of the collaborative learning process via e-learning system. She asserted that collaborative learning via e-learning systems would result in a higher level of student involvement (Hiltz, 1993) and engagement (Harasim, 1990) in the learning process. These productive learning processes will transpire into a higher satisfaction for students.

Hypotheses

According to McGrath's classification (McGrath, 1984), problem-solving can fall into one of two categories, "intellective tasks" or "decision-making tasks." Due to the respective focus of tasks of these two types, the richness of a medium would have different impacts on the performance of the task. For intellective tasks, a rich medium such as audio-conferencing would be distractive with irrelevant information, which could lead to information overload, but would not affect the effectiveness of the task. For decision-making tasks, conversely, a "lean medium" (such as text-based computer system) would be incapable of transferring sufficient information, which could lead to lower efficiency and effectiveness. In addition, using text-based chat rooms would require more time spent on communications, which would affect the users' perception of the efficiency and effectiveness of the communication medium. Therefore, the current study explores the impact of systems on the performance of cooperative learning. Hypotheses are proposed as follows:

For decision-making task:

H1a. The audio-conferencing group has a higher satisfaction level than the text-messaging group in the decision-making task.

H1b. The audio-conferencing group performs better than the text-messaging group in the decision-making task.

For intellective task,

H2a. The audio-conferencing group has the same satisfaction level than the text-messaging group in the intellective task.

H2b. The audio-conferencing group has the same performance as the text-messaging group in the intellective task.

Methodology

Subjects participating in this study were undergraduate students taking an introductory MIS course via an online synchronous learning system. The independent variable in the study is information richness, with text messenger (low information richness) and audio-conferencing (high information richness) as the e-learning systems. The dependent variables are learning satisfaction and performance. Learning satisfaction is a feeling or attitude towards learning activity. A learner has a high learning satisfaction when the learning activity satisfies and meets learning needs and expectations (Tough, 1982). In a pleasant experience with a high level of learning satisfaction, a student is more likely to prefer group discussion, which helps establish a proactive learning attitude between students. Discussants participate in group discussion based on their personal ability, needs, and preferences. The personalized learning experience is one key to the learning satisfaction of group discussion (Douglah, 1970). The authors scored the group discussion results as the measure of cooperative learning performance. The higher the score, the better the learning performance. The moderating variable is group task type, consisting of intellective and decision tasks. Figure 1 is the research framework.

Experimental design

The subjects of this study were students enrolled in an introductory MIS course offered on a synchronous e-learning system in fall semester of 2003. Students of the class were mostly MIS majors or minors. All students had taken an introductory computing course and had reasonable computer skills. Survey forms were collected from 156 subjects who were randomly assigned to 46 groups – 24 using text messaging and 22 using an audio conferencing platform (Table I). The groups discussed their tasks and then completed the survey form for the study. This two-factorial design administered two systems and two task types.

After the random assignment of the subjects to their groups, the tasks for the groups were given, and each group set up a commonly agreeable time to conduct online discussions. Every member of a group logged into the experimental system and conducted a discussion on the given topic with his or her teammates for a period of 50 minutes. During the interaction, members communicated and exchanged through text or audio means. Once an agreement was reached, the group completed and submitted both the survey form and a summarized report. In addition, the investigator stored all information of the discussion for future analyses. Every team finished two tasks (one intellective and one decision making), enabling the process to be repeated, except that the content and nature of the tasks would change. The theme of the decision-making task was:

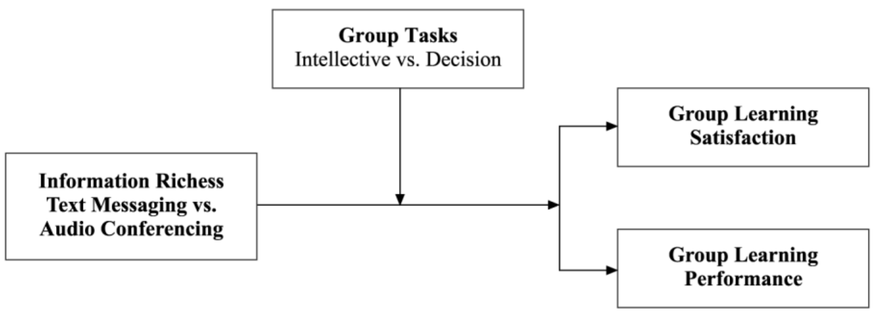

Figure 1.
Theoretical framework

Table I.
Two-factor experiment design

	Text messaging	Audio conferencing
Decision-making task	12 groups	11 groups
Intellective task	12 groups	11 groups

Describe information systems applications for different levels of an organization according to the pyramid model. In your opinion, what information systems can be used to support the duties of the department chair of the MIS department in a university?

There was no single correct answer to the question. Individual group members had their own preferred answers because of their differences in perception and decision-making rationales. Group members needed to rely on the online audio- or text-based chatting to exchange opinions and decided on a preferred answer after reconciling opinions of members. In contrast, the theme of the intellective task was:

Study two company cases (given separately) and analyze their market environments. Identify the competitive strategy adopted by these two companies. Decide which competitive force will be addressed by the adopted competitive strategy, according to Michael Porter's five-force model.

There was a correct answer to the question. Group members needed to find a definite answer based on factual and theoretical backgrounds, resorting to logical inference and their own judgment in order to locate the answer.

To measure the learning satisfaction dimension of learning outcome, a survey was used. The question items on the survey form were extracted from surveys in published research that were tested over time. Specifically, the items were adopted from Alavi's (1994) and Hiltz' (1993) studies. Alavi's study shows that enhancing self-described learning, learning interest, and perceived skill development and class evaluation can contribution to collaborative learning. Hiltz's questionnaire was developed to assess collaborative learning effectiveness in the virtual classroom. The items included in the survey instrument were the ones measuring learning interest, perceived learning development, self-described learning, and group evaluation. The questions were translated to Chinese and rearranged into the survey form used for this study.

Factor analysis

In this section, the four constructs measuring learning satisfaction – perceived learning development, self-described learning, learning interest, and group evaluation – were analyzed. Factor analysis was employed to reveal the intrinsic structure and relationship of the constructs. The Kaiser-Meyer-Olkin's test and Bartlett's test of sphericity were conducted to assure the suitability of the survey data for factor analysis. The results of the tests are presented in Table II.

Table II shows that Kaiser-Meyer-Olkin's measure of sampling adequacy test is 0.882, meaning that the variables would be very well predicted by the underlying factors (meritorious). The significant level of Bartlett's test of sphericity being 0.000 also indicates that the data are appropriate for factor analysis.

Kaiser-Meyer-Olkin's measure of sampling adequacy test	0.882
Bartlett's test of sphericity	
Approx. x^2	2,145.299
Degrees of freedom	325
Significance	0.000

Table II. Learning satisfaction's Kaiser-Meyer-Olkin's test and Bartlett's test of sphericity

Factor analysis with rotation was performed. Factor loadings were estimated using primary component analysis, and rotations were performed using Varimax method. The results are as presented in Table III. The rotated principal component analysis (PCA) method is to: discover the dimensionality of the four constructs, and more precisely identify new meaningful underlying variables. Five constructs have eigenvalues greater than 1 and an additional construct needs to be extracted and retained according to the Kaiser (1960) criterion. The remaining constructs with eigenvalues less than 1 are ignored. The additional factor – self-initiated learning – comprising three question items as follow:

(1) Accomplish my tasks with self-initiative
(2) Enhance capability in analyzing contents
(3) Discuss topics more effectively

Table IV shows the rotated factor matrix for learning satisfaction. The survey items used to measure the five factors of group satisfaction are also included in the same table. As shown in Table IV, the items now load well on their respective factors.

ANOVA analysis

The ANOVA results for decision-making tasks show that the audio-conferencing group had a higher satisfaction level than the text-messaging group. However, both groups had the similar learning performances (Table V). This indicates that the factor of information richness has a significant impact on the learning satisfaction. Hypothesis *H1a.* is supported. The ANOVA results show that the audio-conferencing group has same satisfaction level, as well as learning performance, as the text-messaging group for the intellective task (Table VI). This indicates that the factor of information richness has little impact on the satisfaction level of online groups when the groups undertake intellective tasks. Hypothesis *H2a.* is supported. The factor of information richness also has little impact on learning performance. Therefore, our findings also supported Hypothesis *H2b.* Table VII summarized the results of the hypothesis tests.

Discussion

The group performing on the audio-conferencing platform had a higher satisfaction level than the group performing on text messaging platform. Given the same time interval, audio-conferencing is more effective than text-messaging in improving a group' s satisfaction level for decision-making tasks. This indicates that information richness is an important factor in improving a group' s satisfaction level for decision-making tasks. A shorter response time, tone expressions as stronger social cues, personalized learning experiences, and a closer F2F interaction are all effective conduits of information richness in the audio-based medium. A text-messaging systems platform is thinner in these conduits, thereby contributing to a less satisfactory learning experience. Although an audio-conferencing platform can also deliver a higher learning performance than text messaging in conducting decision-making tasks, there were no significant differences between these two

Table III. The results of a PCA for group learning satisfaction

	Total variance								
		Initial eigenvalue			Squared loading			Rotated square loading	
Value	Eigenvalue	Percentage of total variance	Cumul. percentage	Eigenvalue	Percentage of total variance	Cumul. percentage	Eigenvalue	Percentage of total variance	Cumul. percentage
1	10.177	39.142	39.142	10.177	39.142	39.142	4.316	16.599	16.599
2	2.716	10.448	49.590	2.716	10.448	49.590	3.788	14.571	31.170
3	1.405	5.405	54.995	1.405	5.405	54.995	3.196	12.294	43.464
4	1.175	4.518	59.514	1.175	4.518	59.514	2.715	10.443	53.907
5	1.027	3.950	63.464	1.027	3.950	63.464	2.485	9.557	63.464
6	0.937	3.606	67.069						
7	0.837	3.221	70.290						
8	0.810	3.117	73.407						
9	0.670	2.575	75.982						
10	0.655	2.518	78.500						
11	0.630	2.422	80.922						
12	0.560	2.154	83.076						
13	0.551	2.118	85.194						
14	0.500	1.924	87.118						
15	0.441	1.696	88.814						
16	0.416	1.599	90.413						
17	0.390	1.499	91.912						
18	0.328	1.260	93.172						
19	0.314	1.207	94.380						
20	0.286	1.098	95.478						
21	0.262	1.007	96.485						
22	0.246	0.946	97.431						
23	0.229	0.880	98.311						
24	0.172	0.660	98.971						
25	0.152	0.586	99.557						
26	0.115	0.443	100.000						

Note: Extraction: principal components

Table IV.
Rotated factor matrix for learning satisfaction [a]

Construct	Survey items	Factor 1	2	3	4	5
	Explore relations among important topics	***0.722***	0.287	0.179		0.256
	Develop new friendship	***0.706***	0.192	0.326		0.181
	Enhance critical thinking	***0.645***	0.244	0.384		0.143
Perceived learning development	Learn to respect others' opinions	***0.629***	0.269	0.155	0.177	
	Have me think ethical issues of network	***0.608***		20.128		0.510
	Have me think independently	***0.588***	0.443	0.225		
	Enhance my capability of integration	***0.573***	0.400	0.361		0.131
	Let me understand myself better	***0.470***	0.416	0.250		0.147
	Better understanding of basic concepts					
	Learn a lot of concrete knowledge	0.146	***0.747***	0.122		
	Better command of main themes	0.405	***0.655***	0.117	0.120	0.112
Self-described learning	Finish reading tasks for discussions	0.497	***0.655***	0.122		0.220
	Express my opinions more confidently	0.229	***0.627***	0.250		0.353
	Improve my competence on computer	0.266	***0.589***	0.237		0.151
	Have me do extra reading	0.319	***0.526***	0.230		0.452
	More active participation in discussions					
Learning interest	More interested in the theme of the course	0.225	0.181	***0.808***		0.202
	Willing to discuss-related topics after class	0.147	0.231	***0.801***		0.133
	Sense of achievement	0.341	0.168	***0.693***		0.233
	Understanding-related issues	0.468	0.271	***0.577***		0.259
Group evaluation	Help to improve my own studies					
	Satisfied with outcomes of OL learning				***0.773***	
	Appreciate the richness of the course	20.120	0.179		***0.767***	0.133
Self-initiated learning	Accomplish my tasks with self-initiative				***0.744***	20.123
	Enhance capability in analyzing contents	0.106	20.186		***0.679***	
	Discuss topics more effectively		0.158		***0.648***	
		0.139	0.207	0.323		***0.784***
		0.271	0.249	0.295		***0.737***
		0.191	0.431	0.313	20.104	***0.513***

Notes: Extraction method: primary component analysis; rotation method: Varimax with Kaiser normalization; [a]rotation converged in ten iterations online synchronous learning systems. This finding is contrary to Hypothesis *H1b.* and indicates that the factor of information richness has subjective effects but does not necessarily affect learning capability.

Research findings and implications

For decision-making tasks, audio conferencing has significant impact on learning satisfaction but not on learning performance; for intellective tasks, neither audio conferencing nor text messaging has an impact on learning outcomes. There are no cross-effects between platforms and task types on learning outcomes. This result indicates that the main effects of information richness and task types are independent.

Table V. ANOVA results for decision-making tasks

Systems DV	Text-messaging Mean (SD)	Audio-conferencing Mean (SD)	Sig.
Learning satisfaction	19.752 (0.885)	20.133 (0.928)	0.021*
Learning performance	74.667 (8.773)	78.273 (11.464)	0.404

Note: $^{*}p \le 0.05$

Table VI. ANOVA results for intellective tasks

Systems DV	Text-messaging Mean (SD)	Audio-conferencing Mean (SD)	Sig.
Learning satisfaction	19.779 (1.481)	19.593 (1.279)	0.752
Learning performance	72.417 (12.280)	73.909 (11.211)	0.765

Note: $^{*}p \le 0.05$

Table VII. Summary of hypotheses testing

H1.: decision-making tasks		*p*-value	Supported
H1a.	*H1a*: The audio-conferencing group has a higher satisfaction level than the text-messaging group in the decision-making task	0.021*	Yes
H1b.	*H1b.*: the audio-conferencing group performs better than the text-messaging group in the decision-making task	0.404	No
H2.: intellective tasks			
H2a.	*H2a.*: the audio-conferencing group has the same satisfaction level as the text-messaging group in the intellective task	0.752	Yes
H2b.	*H2b.*: the audio-conferencing group has the same performance as the text-messaging group in the intellective task	0.765	Yes

Note: $^{*}p \le 0.05$

In other words, the impact of information richness on group discussion processes can be examined without needing to consider task types, since the latter would not affect the impacts of information richness. Likewise, the impact of task types on group discussion processes can be examined independently, since the online synchronous learning systems used to facilitate group discussions would not affect the impacts of task types.

The findings maintain merit to some extent because of the appropriate experimental design and execution of the experiments, as well as the data analyses performed. The findings, therefore, imply that, while being independent from each other (without cross effects), the impacts of information richness and task types on learning outcomes can be independently identified and then added together to find combined effects. The study and prediction of the impacts of specific systems and task types on learning outcomes can then be relatively straightforward tasks. This finding has theoretical as well as operational significance for future studies. Building on the results of this study, future research can probe other task types (other than intellective and decision-making tasks) to confirm whether or not interaction still exists between information richness and task types. In terms of the technology, one suitable future investigation would be to verify whether or not the positive effect of audio-conferencing on learning outcomes would be present if audio has delays (which are common in VoIP systems). Overall, research undertakings that continue to answer the question "how do these choices of tasks, technologies, and processes affect the achievement of learning outcomes" (Sharda *et al.*, 2004, p. 54) will be worthy ones to pursue.

Limitations

Because learning based on computer-facilitated systems was in its fledgling stage at the university, the subjects were limited to students of the introductory MIS course, which in turn limited the number of available subjects. Not all groups had the same number of students, which led to the reduced number of groups that could be used as reliable sources of data collection and observation. Because of the above limitations, the sample may not be sufficiently representative to allow wider generalization of the findings of this study. Therefore, caution should be used when the findings of this study are being generalized. One potential problem is that the subjects may not have gained sufficient expertise in using the systems due to the short time-span of each session of the experiment; they could have just been getting familiar with the system during the intended experiment duration rather than using the system in a "normal operational mode." This can potentially affect the consistency of the subjects' perception and performance on the systems.

In the current study, only text- and audio-based online learning systems were involved in online discussions. If video systems are introduced, more clues and richer socialization processes may be present, which may more closely mimic the natural personal interactions among the subjects. It is yet to be found whether the same results will be reached with video-based systems added for online discussions. In addition, this study employed as subjects college students using online instruction systems. With the growing popularity of e-learning for corporate training, determining whether or not the results would be different for corporate users is a direction worth probing. Future research may study other task types (other than decision-making or intellective), as well as employ longer experiment times (both the number of sessions and the length of each session) and different task formats (other than projects). New results may be found in those new settings of research.

Conclusion

This empirical study created a controllable environment to allow the interaction of factors involved in cooperative e-learning processes to occur and unfold. Group discussions for different types of tasks on different synchronous e-learning systems were observed. Possible effects on learning satisfaction and performance by different types of tasks and/or on different systems were identified and inferred. First, data analyses based on our experiments indicate that decision-making tasks conducted on an audio conferencing platform result in higher learning satisfaction. Compared to using text messaging in which the slower typing speed of some members may cost the group longer waiting time, conducting group discussion on audio conferencing platforms fits the accustomed oral communications and increases the ease of use and, therefore, learning satisfaction.

Second, our data analyses show that systems (the artifact of information richness) or task types do not have an impact on learning performance. In other words, the main effects of information richness and task types are independent as far as learning outcomes are concerned. This is an interesting result with potentially far-reaching implications. Third, the learners' attitude toward the synchronous learning system significantly affects the satisfaction of synchronous online learning. Results of data analyses show that the groups with more positive attitude toward the computer systems, the reliability of computer systems, the interactivity of the system, and the interface user-friendliness, have higher learning satisfaction. Consequently, before the learners conduct learning activities using the synchronous discussion systems, they should be encouraged to get familiar with and practice the related methods of using the specific learning systems so that the synchronous discussion systems will not inadvertently become a hurdle to learning resulting in process loss.

References

Ahituv, N., Neumann, S. and Riley, H.N. (1994), *Principles of Information Systems for Management*, Wm. C. Brown, Dubuque, IA.

Alavi, M. (1994), "Computer-mediated collaborative learning: an empirical evaluation", *MIS Quarterly*, June, Vol. 18 No. 2, pp. 159-74.

Alavi, M. and Leidner, D. (2001), "Research commentary: technology-mediated learning – a call for greater depth and breadth of research", *Information Systems Research*, Vol. 12 No. 1, pp. 1-10.

Beck, P.O., Kung, M.T., Park, Y-T. and Yang, S.C. (2004), "E-learning architecture: challenges and mapping of individuals in an internet-based pedagogical interface", *Internal Journal of Innovation and Learning*, Vol. 1 No. 3, pp. 279-92.

Brown, A.L. and Palincsar, A.S. (1982), "Inducing strategic learning from texts by means of informed, self-control training", *Topics in Learning and Learning Disabilities*, Vol. 2 No. 1, pp. 1-17.

Coleman, J.S. (1988), "Social capital in the creation of human capital", *American Journal of Sociology*, Vol. 94, pp. 95-120.

Contractor, N.S. and Eisenberg, E.M. (Eds) (1990), *Communication Networks and New Media in Organizations*, Sage, Newbury Park, CA.

Daft, R.L. and Lengel, R.H. (Eds) (1984), *Information Richness: A New Approach to Managerial Information Processing and Organization Design*, JAI Press, Greenwich, CT.

Daft, R.L. and Lengel, R.H. (1986), "Organizational information requirements, media richness and structural design", *Management Science*, May, pp. 554-71.

Doll, W.J. and Torkzadeh, G. (1988), "The measurement of end-user computing satisfaction", *MIS Quarterly*, Vol. 12, pp. 259-74.

Douglah, M. (1970), "Some perspectives on the phenomena of participation", *Adult Education*, Vol. 20 No. 2, pp. 629-40.

Ellis, D.G. and Fisher, B.A. (1994), *Small Group Decision Making-Communication and Group Process*, McGrath-Hill, Inc., New York, NY.

El-Shinnawy, M.M. and Markus, M.L. (1997), "The poverty of media richness theory: explaining people's choice of electronic mail vs. voice mail", *International Journal of Human-Computer Study*, Vol. 46 Nos 2/3, pp. 443-67.

Evans, E. and Wurster, T. (1999), *Blown to Bits: How the New Economics of Information Transforms Strategy*, Harvard Business School Press, Boston, MA.

Fjermestad, J. and Hiltz, S.R. (2001), "Group support systems: a descriptive evaluation of case and field studies", *Journal of Management Information Systems*, Vol. 17 No. 3, pp. 115-60.

Fjermestad, J., Hiltz, S.R. and Turoff, M. (1995), "Group strategic decision making: asynchronous GSS using structured conflict and consensus approaches", *Proceedings of the 28th Annual Hawaii International Conference on System Sciences*,Vol. IV, IEEE Computer Society Press, Los Alamitos, CA, pp. 222-31.

Fulk, J. (1993), "Social construction of communication technology", *Academy of Management Journal*, Vol. 3 No. 6, pp. 921-50.

Glaser, R. and Bassok, M. (1989), "Learning theory and the study of instruction", *Annual Review of Psychology*, Vol. 40, pp. 631-66.

Harasim, L. (1990), *On-line Education: Perspectives on a New Environment*, Praeger, New York, NY.

Harasim, L. (1993), "Networlds: networks as a social space", in Harasim, L. (Ed.), *Global Networks: Computers and International Communication*, MIT Press, Cambridge, MA, pp. 15-34.

Hillman, D.C., Willis, D.J. and Gunawardena, C.N. (1994), "Learner-interface interaction in distance education: an extension of contemporary models and strategies for practitioners", *The American Journal of Distance Education*, Vol. 8 No. 2, pp. 30-42.

Hiltz, S.R. (1993), *The Virtual Classroom: Learning without Limits via Computer Network*, Albex Publishing Corporation, Nor Wood, NJ.

Hirumi, A. and Bermudez, A. (1996), "Interactivity, distance education, and instructional systems design converge on the super information highway", *Journal of Research on Computing in Education*, Vol. 24 No. 1, pp. 1-16.

Horn, D. (1994), "Distance education: is interactivity compromised?", *Performance and Instruction*, Vol. 33 No. 9, pp. 12-15.

Johnson, D.W. and Johnson, R.T. (1994), *Learning Together and Alone: Cooperation, Competition, and Individualization*, Allyn & Bacon, Needham Heights, MA.

Kaiser, H.F. (1960), "The application of electronic computers to factor analysis", *Education and Psychological Measurement*, Vol. 20, pp. 141-51.

Khalifa, M. and Kwok, R.C.W. (1999), "Remote learning technologies: effectiveness of hypertext and GSS", *Decision Support Systems*, Vol. 26, pp. 195-207.

Kim, A.J. (2000), *Community Building on the Web: Secret Strategies for Successful Online Communities*, Peachpit Press, Berkeley, CA.

Kwok, R.C.W., Jian, M. and Vogel, D.R. (2002), "Effects of group support systems and content facilitation on knowledge acquisition", *Journal of Management Information Systems*, Vol. 19 No. 3, pp. 185-229.

Kwok, R.C.W. and Khalifa, M. (1998), "Effect of GSS on knowledge acquisition", *Information & Management*, Vol. 34, pp. 307-15.

Lee, A.S. (1994), "Electronic mail as a medium for rich communication: an empirical investigation using hermeneutic interpretation", *MIS Quarterly*, Vol. 18 No. 2, pp. 143-57.

Leidner, D.E. and Fuller, M. (1997), "Improving student learning of conceptual information: GSS supported collaborative learning vs. individual constructive learning", *Decision Support Systems*, Vol. 20, pp. 149-63.

Leidner, D.E. and Sirkka, L.J. (1995), "Information technology to support management education: a theoretical view", *MIS Quarterly*, September, pp. 265-92.

McGrath, J.E. (1984), *Group: Interaction and Performance*, Prentice-Hall, Englewood Cliff, NJ.

McGrath, J.E. and Altman, I. (1996), *Small Group Research: A Synthesis and Critique of the Field*, Holt Rinehart & Winston, New York, NY.

McHenry, L. and Bozik, M. (1997), "From a distant student voices from the interactive video classroom", *TechTrends for Leaders in Education & Training*, Vol. 42 No. 6, pp. 20-4.

Markus, L.M. and Robey, D. (1988), "Information technology and organizational change: causal structure in theory and research", *Management Science*, Vol. 35 No. 5, pp. 583-98.

Moore, M.G. (1989), "Three types of interaction", *The American Journal of Distance Education*, Vol. 3 No. 2, pp. 1-6.

Sharda, R. *et al.*, (2004), "Foundation for the study of computer-supported collaborative learning requiring immersive presence", *Journal of Management of Information Systems*, Vol. 20 No. 4, pp. 31-63.

Sherry, L. (1996), "Issues in distance learning", *International Journal of Educational Telecommunications*, Vol. 1 No. 4, pp. 337-65.

Tough, J. (Ed.) (1982), *Language, Poverty, and Disadvantage in School*, Academic Press, New York, NY.

Trevino, L.K., Lengel, R.H., Bodensteiner, W., Gerloff, E.A. and Muir, N.K. (1990), "The richness imperative and cognitive style", *Management Communication Quarterly*, Vol. 4 No. 2, pp. 176-97.

Turner, J.H. (1991), *The Structure of Sociology Theory*, Wadsworth, Belmont, CA.

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