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ABSTRACT

The boom in the application of information technologies to education and training, e-learning, underscores a fundamental need to understand how these technologies improve the learning process. Yet, very little Information Systems research is focusing on this issue. A review of education literature points out that learning strategies are shifting towards a more collaborative learning. In this paper, we articulate a theoretical lens for further research in collaborative e-learning. The main focus here is on understanding the structures involved due to a given learning strategy, interactions among structures, their appropriation as well as the impact of structures on learning outcomes. Three types of structures -- collaborative, technology and learning task -- are identified and interactions between them highlighted. We also outline key research issues within collaborative e-learning.

Key Words

Collaborative e-learning, theoretical framework, task-technology fit, adaptive structuration, research directions

INTRODUCTION

Universities and corporate training facilities have been investing in information technologies to improve education and training at an increasing rate during the past decade. Many new companies are emerging to provide tools and services to enable the effective design of IT-based learning solutions. We are seeing similar trends in certain parts of Universities and other educational institutions. Although research on technology-mediated learning has increased in recent years, it still lags behind developments in practice. Many predict that the biggest growth in the Internet, and the area that will prove to be one of the biggest agents of change, will be online learning, or e-learning (Bostrom 2003). The boom in the application of technology to education and training underscores a fundamental need to understand how these technologies improve learning process.

E-learning research has only recently attracted the attention of Information System (IS) scholars, although the topic has been consistently of interest to educational researchers. In spite of interest, research in this area has been fragmented (Alavi et al. 2001; Bostrom 2003). One of the reasons for this fragmentation is the lack of agreement on definitions and terms, especially e-learning. In this paper, we focus on the definition given by (Alavi et al. 2001) - *Technology-mediated learning* (or e-learning) *is defined as an environment in which the learner's interactions with learning materials, peers, and/or instructor are mediated through advanced information technology".* This definition puts technology at the center of what is being studied and forces the researcher to investigate issues around understanding the technology and its impact (Zmud 2002).

Although the initial focus of e-learning in educational literature has been at the individual level, a review of education literature points out that learning strategies are shifting towards a more active and group-oriented learning referred to as cooperative or collaborative learning (Alavi et al. 1995, Kelly 1998). Collaborative learning (CL) evolved from the work of psychologists such as Johnson et al. (1981) and Slavin et al. (1985). It refers to instructional methods that encourage students to work together to accomplish shared goals, beneficial to all. It involves social (interpersonal) processes where participants help each other to understand as well as encourage each other to work hard to promote learning (Johnson et al. 1999).

CL is a versatile procedure and can be used for a variety of purposes ranging from teaching specific content to ensuring active cognitive processing of information during a lecture or demonstration (Johnson et al. 1992; Johnson et al. 1994). CL procedures have also been found to be more effective than traditional instructional methods in promoting student learning and academic achievement (Johnson et al. 1981, Slavin et al. 1985). In a comparison of CL vis-à-vis traditional classroom learning, researchers found that collaborative approach increases student involvement with the course (Collier 1980, Cooper, 1990) as well as with each other (Cooper, 1990), increases the level of critical & active thinking (Bligh 1972, McKeakie 1980), promotes problem-solving skills (Kulik et al. 1979) and increases student satisfaction (Bligh 1972, Kulik et al. 1979).

In spite of the growing importance of e-learning and CL, important research is lacking in collaborative e-learning (CEL). Most of the research in the education literature has concentrated on face-to-face forms of collaboration or using minimal technology to support it. With advances in information systems, there have been rapid advances in distance learning and virtual team learning. Greater amount of learning is now done using synchronous or asynchronous technology than ever before and there is a dire need to understand this phenomenon in detail. Finally, the research has focused on input-output models, lacking good grounding in theory, rather than focusing on the process involved in attaining the learning outcomes. In this paper, we use the two foundational disciplines, Education and IS, to lay a foundation for future research directions in CEL to address these issues.

In the following sections, we first focus on understanding instructional technology. Section II examines the previous research done in this area and section III provides a theoretical framework for an integrated research view of CEL outlining key research issues.

COLLABORATIVE E-LEARNING INFORMATION TECHNOLOGY

Instructional information technology is the set of communication, structuring and information processing tools that are designed to work together to support the accomplishment of learning tasks (Zigurs et al. 1998). Thus, its three critical dimensions are: communication support, process structuring, and information processing.

Communication support is defined as any aspect of technology that supports, enhances, or defines the capability of group members to communicate with each other (Zigurs et al. 1998). Process structuring is any aspect of technology that supports, enhances, or defines the process by which groups interact, including capabilities for agenda setting, agenda enforcement, facilitation and creating a complete record of group interaction (Zigurs et al. 1998). For example, online breakout rooms force protocols of speaking between participants. Finally, information processing is the capability to gather, share, aggregate, structure or evaluate information, including specialized tools (Zigurs et al. 1998) such as application sharing, shared white board etc.

BRIEF LITERATURE REVIEW

Research in collaborative e-learning (CLE) has two strong reference disciplines: IS and Education. As mentioned earlier, IS e-learning research has been very limited especially in CLE area, with only a limited set of papers focused on CLE. The empirical research in IS stems from the long tradition of GSS research with its focus on process gains/process losses in collaborative settings. Some studies have explored the use of GSS to foster case discussions in a traditional classroom (Hashaim et al. 1991; Leidner et al. 1997). Others have examined the use of GSS to enable collaboration in small teams of students in traditional classes. These findings suggest that GSS supported groups out perform the non-supported groups (Alavi 1994). Also, Lim et al. (1997) suggests that co-discovery (a form of CL) forced learners to engage in deeper level thinking that facilitated improved individual learning. Table 1 summarizes the research in IS in this area.

A meta-analysis 375 studies of CL in the education literature, Johnson et al. (1991) provided compelling evidence to the relative effectiveness of CL in terms of learning achievement, student satisfaction with learning process and outcomes, and quality of interpersonal relationships and emotional climate in the learning environment. In a more recent meta-review, Lou et al. (2001) examined 122 studies for comparison between small groups versus individual learning when students learn using computer technology. The meta-analysis indicates that, on average, small group learning has significantly more positive effects than individual learning on student individual achievement, group task performance and several process and affective outcomes. This is consistent with IS research in this area. The important structures accounting for the variance in the outcomes were technology, task, group and learner characteristics. For details refer to Lou et al. (2001).

Both, IS research (as seen in Table 1) and Education (Lou et al. (2001); Johnson et al. (1991)) show that much of the past research has focused on input-output research designs, comparing the impact of technology-mediated learning in individuals versus small groups on different learning outcomes. Thus, we have strong evidence that IS technology and collaboration, separately and together can have positive impact on learning outcomes. Our focus needs to change to the learning process to investigate the following research question: How does technology enhance learning in a given context (students, instructor/mentor, instructional method, environmental factors)?

Author	Learning context	Major findings
Alavi et al. (2002)	Distributed learning environment Comparing two kinds of electronic mediation – simple and sophisticated	Simple systems users exchanged more messages about learning task whereas sophisticated system users spent more time on sense-making about the technology Learning outcomes were higher for simple system users
Hiltz et al. (2000)	A 2X2 experimental design comparing classroom to online learning and individual to groups	Participants who are actively involved in collaborative (group) learning on-line, the outcomes can be as good as or better than those for traditional classes, but when individuals are simply receiving posted material and sending back individual work, the results are poorer than in traditional classrooms.
Leidner et al. (1997)	Quasi experimental design for case analysis	Students involved in IT-based collaborative learning showed higher levels of interest in learning than individual learners, but lower levels of performance
Lim et al. (1997)	Experiment of setting up a meeting date with participants.	Co-discovery forces learner to engage in deeper level thinking Co-discovery learners generated more occurrences and larger proportion of deeper level utterances than did self-discovery subjects
Alavi et al. (1995)	Comparing collaborative learning in one campus and teams spanning across campuses	Different learning environment were found to be equally effective, however , higher critical thinking was found in distant technology mediated environment Distant students using technology mediation were more committed and attracted to their groups compared to local students who worked face to face or were technology mediated.
Alavi (1994)	Comparing groups using GDSS versus groups not using and impacts on student learning and classroom experiences	Learning outcomes of GSS supported student teams is superior to non-supported teams
Hashaim et al. (1991)	Classroom setting for case discussion	Groupware system helped students and instructors guide the discussion towards its ultimate conclusion, keeping in mind the specifics of the situation as well as experience gained from past case discussions

Table 1: IS research in technology mediated collaborative learning

In addition, most of instructional technology research in Education has focused on content-delivery, designed for individuals, whereas, most IS research has focused on technology to support collaboration, not content-delivery. In a typically education study, teams would sit around computer system going through content together. We are starting to see much richer blended technologies environments being used but there is little research on these new environments.

Recently, Alavi et al. (2002) provided a framework for e-learning research that explicitly configures the relationships among technology capabilities, instructional strategy and psychological processes involved in the learning process. Apart from highlighting the lack of theoretical base for understanding this area, this framework also highlights the importance of focusing on the learning process although it does not provide a lens for focusing. In addition, both past research and this framework do not address the links between technology features and instructional and collaboration variables that might influence the learning process.

THEORETICAL LENS: ADAPTIVE STRUCTURATION THEORY (AST)

Drawing on the Alavi et al. (2002) framework and integrating two important theories into it from the GSS literature namely task-technology fit [TTF] (Zigurs et al. 1998) and adaptive structuration [AST] (Poole et al. 2003), we create a research framework for investigating collaborative e-learning. AST provides lens for looking at the learning process, while TTF provides lens for looking at links between key input structures: collaboration, technology and learning tasks.

The model, shown in Figure 1, highlights the fact that learning achievements, based on a learning strategy, are governed by a fit between collaborative, technology and learning tasks structures. The model also argues that these fits are a necessary but not a sufficient condition to improve learning performance. Without proper appropriation, performance is less likely to improve even if fit exists (Dennis et al. 2001).

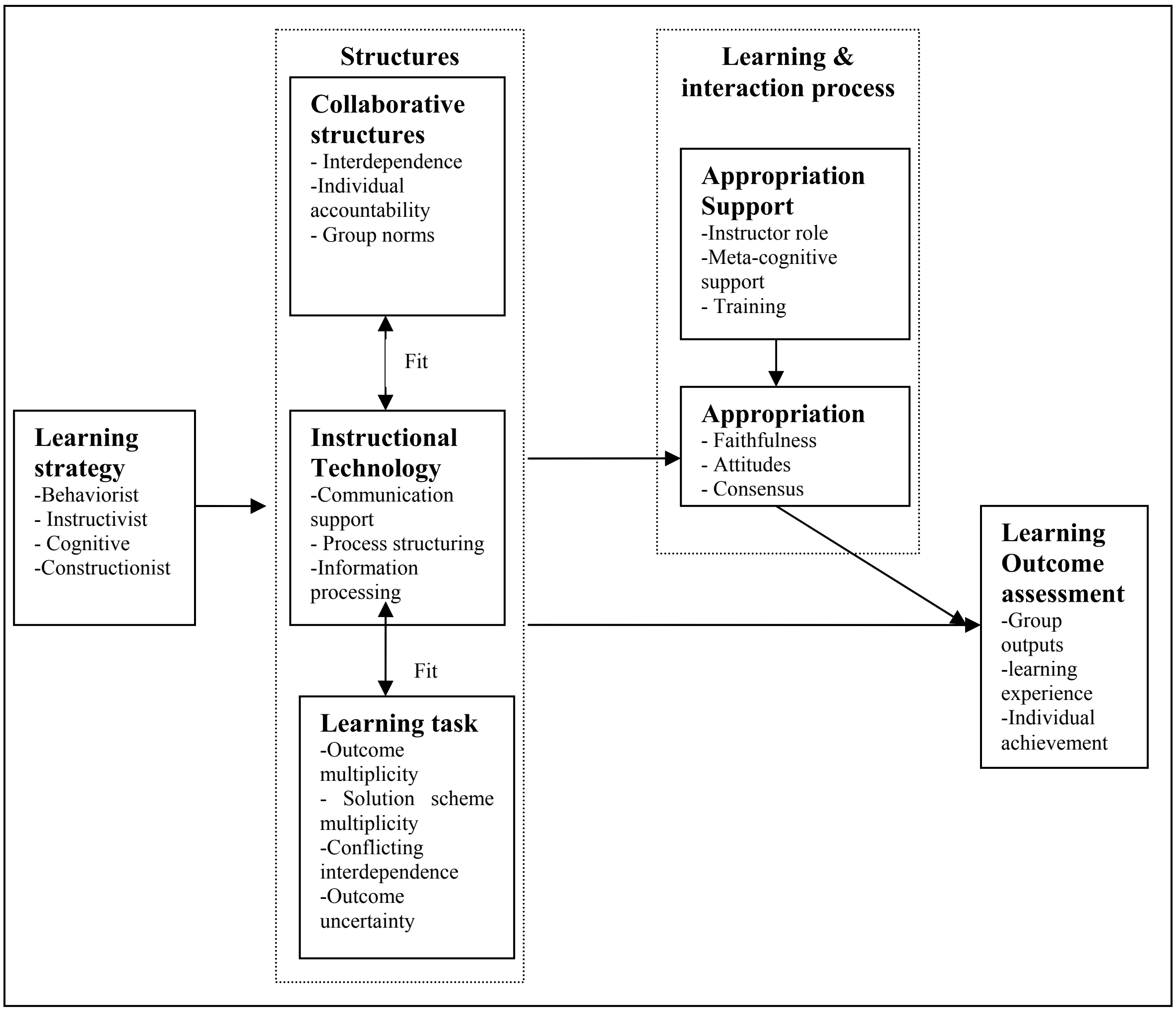

Figure 1 : Research framework for Collaborative e-learning

Learning strategy here refers to the approach that the individual takes to achieving the predefined learning outcomes (O'Neil 1978). The choice of strategy by the teacher, trainer or instructional designer further imposes the structures that serve as templates for further activity. Structures are formal and informal procedures, techniques, skills, rules and technologies that organize and direct group behavior processes. Three forms of structures are identified here i.e. collaborative structures which refer to the social setup of the group (Johnson et al. 1999); instructional technology structures which present an array of technology features for possible use in interpersonal interaction and cognition (DeSanctis et al. 1994); and learning task structures, which provide structures for participants to absorb the knowledge (Mowrer et al. 2000). These three structures together provide a basis for group interaction and subsequent learning.

Appropriation is the fashion in which the group uses, adapts and reproduces a structure (Poole et al. 2003). Appropriation may be supported by providing training, though facilitation or other forms of support. When well-designed and relevant structures are successfully appropriated, the group interaction will be improved, which should in turn contribute to higher quality learning outcomes in terms of attainment of knowledge, skills, mental models etc. evaluated through various forms of assessments such as tests (Anson et al. 1995). An unfaithful appropriation, on the other hand, might result in lower learning outcomes. A recent study by (Alavi et al. 2002) highlights this issue where participants with sophisticated systems had lower learning outcomes because of lack of appropriation of technology. This was primarily due to lack of training support as participants spend more time in understanding the technology rather than focusing on learning objectives.

Poole et al. (1989) suggest three dimensions which affect how successfully a structure is appropriated: Faithfulness, attitudes and level of consensus. That is, a structure will only have its intended effect if its design principles are kept intact (faithfulness), if members do not react negatively to it (attitudes), and if members are in substantial agreement over how structure is used (consensus).

As cited earlier, an extensive amount of research exists in the educational literature on CL. Most of it has focused on collaboration and learning task structures. Most IS research has focused on technology structures. Neither literature has focused on relationship between these structures nor how they are appropriated and used in the learning process. We believe the model in Figure 1 and the theories embedded in the model provide a rich lens for investigating technology impacts on learning. The remainder of this paper will focus on the interaction/links between technology & collaborative structures and between technology & learning tasks structures.

Learning Strategy

There are many different learning tasks ranging from on the job training, to case studies to lectures that can be done as a part of the learning strategy. A learning strategy is the approach to learning task, which includes planning, executing, and evaluating performance on a task and its outcomes. Thus, learning strategy provides the basic framework which guides the design of the various possible learning tasks. Many different forms of learning strategy (Leidner et al. 1995) have been explored in the literature. Many of these schools overlap in dimension and thus, cannot be independently isolated. Also, early efforts to come up with a global comprehensive theory of learning were unsuccessful and abandoned (Mowrer et al. 2000). We, thus, focus on the four fundamental schools of thought when it comes to learning: instructivist, behaviorist, congnitivism and constructivism (Leidner et al. 1995; Mowrer et al. 2000; Reeves et al. 1997) which represent a comprehensive as well as mutually exclusive framework. All four are relevant and play an important role in the field of designing educational curriculum.

The behaviorist design is based on the presumption that human behavior is predictable. Under this theory, learning occurs when new behaviors or changes in behaviors are acquired as the result of an individual's response to stimuli. Thus, the end goal is defined up front, and each step necessary to achieve the goal is given to the group. Examples of such an approach are factual learning tasks.

Instructivists stress the importance of objectives that exists apart from the learner. They espouse an objective epistemology that defines knowledge as separate from knowing. The focus here is on acquiring that knowledge. Thus, once one or more objectives are identified, they are sequenced into learning module. For example, codiscovery techniques believe that solutions to tasks exists and can be discovered together by people.

Cognitive theory states that learning is a process that is dictated by the participants previous experiences, and how the information is presented to the student. Under this theory, learning is a change in the knowledge stored in the memory by modifying mental representations. Thus, tasks under this theory are has a predefined goal along with information necessary to reach the goal, but the process of cognition of the information is left to the group. Examples of such an approach are problem-solving tasks.

Constructivism theory says that individuals construct knowledge by working to solve realistic problems. Under this theory, learning is the process where individuals construct new ideas or concepts based on prior knowledge and/or experience. Constructivists believe the environment needs to be highly adaptive to the participant. A constructivist designer might provide all the information necessary for learning, but will allow the student to learn the materials and information that is most comfortable to the student to arrive at their own conclusion. Learning groups are presented with an idea about the solution, and the tools necessary are provided, but the group is left on its own to figure out the exact solution, and thus, the process required to reach it. Example of such an approach is the case study method.

Each of the above learning strategies can be used to guide the selection of structures in a collaborative environment.

Technology & Task Structure Fit

Missing from both Educational and IS literatures is a focus on learning task-technology fit (TTF). We believe that the IS TTF theory and research focusing on other tasks is a good starting point (Zigurs et al. 1998). Venkatraman et al (1990) suggested that a test of task-technology fit would require three steps: (1) identifying distinct task environments, (2) specifying ideal technology support for each task and (3) testing the performance effects of task/technology alignments. In this section, we focus on the starting step for research in this area, a model for identifying distinct learning task environments.

Task/technology fit is defined as the ideal profiles composed of an internal consistent set of task contingencies and instructional technology elements that affect group-learning outcomes (Zigurs et al. 1998). The greater the degree of adherence to an ideal profile, the better the performance of the group. In order to develop these profiles research needs to focus on (Venkatraman et al 1990) the last two steps, i.e. specifying ideal technology support for each learning task and testing the performance effects of task/technology alignments.

Table 2 summarized the prescriptions of task/technology theory, i.e. the table shows the fit profiles that are expected to enhance learning outcomes. The terms low, medium and high have been used as an approximation for the level of support prescribed. The discussion that follows revels that each of the learning task categories imply particular technology support i.e. outcome multiplicity implies a need for processing support; solutions scheme multiplicity implies information processing support; and conflicting interdependence as well as solution scheme uncertainty implies communication support (Zigurs et al. 1998).

Learning task type	***Communication support***	***Process structuring***	***Information processing***
Behavioral	Low	Low	Low
Instructiveist	High	Low	High
Cognitiveist	Low	Low / High	High
Constructivist	High	Medium	High

Table 3: Learning task type - Instructional technology fit matrix

Tasks designed with behaviorist strategy have a single desired outcome in terms of a behavior or skill as well as a well defined way to achieve that behavior or skill. Therefore, all the participants of the group need is being able to access and communicate this solution scheme, requiring minimal communication support. Too much structure or focus on information processing could interfere with simple communication needs and detract from learning outcome (Gallupe et al 1998).

Tasks with an instructivist strategy assume that there is knowledge out there and it needs to be search for and presented correctly. Thus, there is high need for information processing tools. Participants have to be able to search and aggregate the right information to achieve the learning objectives. Communication support should be low – sufficient to provide minimal capabilities for communicating information essential while avoiding communication overload. Processes structuring should also be low, since such task do not imply extensive steps that might need agenda support or enforcement of too much structure that could prevent exploration for information.

Cognitive strategy based task require the participants to accomplish task together, while making their own independent mental models. This need to accomplish the task together requires high information processing tools, especially analytical tools. Communication support should be low – sufficient to provide information for exchange of information while avoiding communication overload. Process structuring is important to ensure that, in spite of different individual metal models, group accomplishes the task.

Tasks of constructivist nature have a very broad goal, and participants learn by spending most of their effort on understanding and structuring the task. Information load, information diversity, conflict and uncertainty are all a part of the constructivist approach. Where complexity is high, enhanced information processing is important (Rana et al. 1997). The greatest emphasis, therefore, should be on communication among group members, gathering of information and presenting in correctly. Process structuring is also important to the extant that it helps groups organize, as well as communicate in a better mechanism.

The framework presented in Table 3 provides a good outline for distinctly identifying separate task environments. Further research is needed in empirically exploring the validity and usefulness of this classification scheme. Given the plethora of technology tools available, IS researchers also need to focus research on trying to identify the appropriate set of technology tools needed to perform each of these tasks. Finally, the learning outcomes based on these task-technology fit should be empirically tested to develop best practice task-technology fits for different learning tasks.

Technology & Collaboration Structure Fit

Even if only used for scheduling or transfer of documents, most learning groups today use some form of information technology. Thus, the new conceptualization of collaborative e-learning (CLE) should be related to the amount of information technology use (Niedeman et al. 1999). However, this is likely to be moderated by the amount of continued traditional collaboration activity in the group. A group collaborating solely though technology is clearly different from one with an equal amount of collaboration though electronic media but with additional communication in traditional face-to-face mode. Based on the modes for collaboration, groups are classified on two dimensions - the extent of technology-mediated collaboration and the extent of traditional/face-to-face collaboration. Spitting these measures into high and low levels leads to four categories shown below in Figure 2. Each of these categories is described below:

Technology mediation collaboration	***Traditional / Face-to-Face collaboration***		
		Low	High
	Low	Q1: Pseudo learning group	Q2: Traditional learning group
	High	Q3: Pseudo virtual learning group	Q4: Virtual learning group

Figure 2: Technology mediated learning framework

- Pseudo learning group (Q1): Groups in this quadrant meet infrequently electronically or face-to-face. Participants in this group are assigned to work together but often they have no interest in doing so and believe they will be evaluated by being ranked from the highest to the lowest performer. Students would achieve more if they were working alone (Johnson et al. 1999). If forced to use technology, it will act as a hindrance to the actual learning process as participants will spend more time trying to understand technology than on the actual task.
- Traditional learning group (Q2): The low electronic and high traditional collaboration would be the traditional learning group bound by geographic proximity. Bulk of the educational psychology research has been in this area and provides a good basis for further speculation. (Johnson et al. 1999). Given the ubiquity of computers, most groups use information processing tools in this area. For example, participants in a group will come together to view a programming code on one computer screen.
- Pseudo virtual learning group (Q3): This group is low on collaboration and the primary use of technology is to communicate or store information. Groups in this quadrant prefer to work individually while communicating electronically. If they are widely dispersed, electronic communication may be the only mechanism by which they can communicate. Similar to Q1, participants use minimal scheduling tools or process structuring tools to assign work. Some groups also use these communication tools as a medium for gathering the finished work from group participants.
- Virtual learning group (Q4): Regardless of where the group members of this category are physically located, they choose to communicate electronically. These include groups using synchronous, asynchronous or using both communication modes. It provides a potential for the richest level of collaboration. A learning group with complex learning outcomes that require high values of individual contribution and much coordination best severed by ability to process information and processes structuring. Initial research in this area has been in comparing learning outcomes in asynchronous learning networks (Hiltz et al. 2000) and comparing between two kinds of systems (Alavi et al. 2002).

Table 2, which summarizes the fit, also helps us categorize different kinds of collaborative strategy and technology interaction. Each of these interactions has different implications on the learning outcomes as mediated by the intervening learning process. Understanding the e-learning technology map (Bostrom 2003) and its interactions in each of these quadrants will provide us with increasing insight into the domain of collaborative e-learning.

Quadrant	***Communication support***	***Process structuring***	***Information processing***
Q1: Pseudo	Not needed	Not needed	Not needed
Q2: Traditional	Low	Low	Medium to high
Q3: Pseudo virtual	High	Medium	Low
Q4: Virtual	High	High	High

Table2: Technology & Collaboration Structure Fit

Much of the educational literature has focused on the Q1 and Q2 quadrants both involving minimal use of technology to support collaboration. With advances in information systems, it is now possible to effectively support Q3 and Q4 quadrants as well and further exploit Q2. IS researchers can exploit their understanding of technology to address various research questions. The collaborative structures needed for effective learning are well known for Q2 (Johnson el at. 1981) and we can assume that they would be similar in other quadrants. Thus, the interesting question is the choice of technology to help implement collaboration structures in other quadrants. In addition, identifying effective combinations of learning and technology structures for Q2-Q4 is critical.

CONCLUDING REMARKS

The declining cost and continued convergence of computing and communication technologies as well as the prevalence of the Internet is making collaborative e-learning an increasingly viable educational alternative. Furthermore, an increase in the requirements for continuous learning and growth in the number of adult, part-time students is creating a "demand-pull" for going beyond the traditional classroom.

In this paper, we articulate a theoretical lens for further analysis into collaborative e-learning area. The main focus is on understanding the structures involved due to a given learning strategy, interactions among those structures, their appropriation as well as its impact on learning outcomes. We have presented frameworks for understanding the interactions between these structures and well as key research topics. Once we understand these interactions, attention also needs to be focused on their appropriation.

The model also raises many other research issues not specifically highlighted in the paper. One such issue is the understanding the implications of various appropriation support mechanisms. For example, training students in using tools in the right spirit might lead to a better appropriation of technology, resulting in better learning outcomes.

In summary, this paper brings together literature from two different disciplines to present a theoretical model for understanding issues involved in collaborative e-learning. Given the substantial rise in the importance of this area to education and business, we strongly encourage IS and educational researchers, separately and together, to focus in this area.

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