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Dimensions of Learning Interaction in the IT-Supported Classroom

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Abstract

Most theories of learning and prescriptive guides for learning enhancement suggest the need for active learning to increase learning effectiveness, yet few studies have questioned how the process of learning interaction affects learning outcomes or student's perceptions of learning outcomes. This research begins to unravel the connection between learning interaction and learning outcome from both an objective and perceptual standpoint. Learning interaction was studied in a laboratory experiment using three delivery mechanisms (software demonstration with lecture, PowerPoint supported lecture, and commercial CBT with facilitator) and two learning models (individual learners and paired learners). Findings suggest that not all interaction leads to increased learning outcomes and learning interaction is a multi-dimensional construct that merits further study.

Keywords: learning interaction, perceived learning interaction, learning models, learning outcome, teaching methods, information technology

Introduction

The effective use of information technology to enhance learning outcomes is an area in need of more research. Specifically, instructors need to understand the processes affecting learners when using information technology. Two research frameworks (Alavi & Leidner, 2001; Piccoli, Ahmed, & Ives, 2001) have focused on the effects of information technologies, identified potential constructs of interest, and emphasized the need for continued research into the effects on learning processes and outcomes. The broad definition of technology-mediated learning (TML) (Alavi & Leidner, 2001) and the more focused definition of virtual learning environments (VLE) (Piccoli et al., 2001) both center on the notion of learner interaction with various aspects of an information technology-supported learning environment. Both research frameworks focus on formal learning environments in which an instructor utilizes selected models of learning and information technologies within an instructional context with the objective of achieving a desired outcome.

The VLE framework defines interaction as the degree of educational exchange and contact focused on learners and instructors. The TML research framework offers a process view that considers instructional and information technologies as inputs to a psychological learning process and the subsequent effect on learning outcomes. Learning interaction is an implied process construct in the TML framework that potentially affects learning outcomes. The motivation for this research is to further the understanding of the dimensions of learning interaction, the measurement of these dimensions, and the effects of the various dimensions on learning outcomes.

Background

Research from fields such as educational technology and distance learning inform our understanding of learning interaction. Learning interaction is called for in the traditional classroom as well as in distance learning and computer supported environments. Most theories of learning as well as prescriptive guides for learning enhancement suggest the need for active learning to increase learning effectiveness (Bonwell & Eison, 1991; Bates, 1995; Smith, 1996). In describing active learning, two contexts for interaction have been identified: individual and social (Bates, 1995). The individual context refers to interaction between the individual learner and learning material, leading to instructional design strategies emphasizing interaction using various teaching techniques (Bonwell & Eison, 1991; Sutherland & Bonwell, 1996). Social context refers to interaction between two or more people and learning content and supports collaborative theories of learning.

Information Technology

A wide variety of information technologies is available to support learning in both traditional and non-traditional environments (Bates, 1995). These technologies provide top-down, bottom-up, and horizontal information flows and include synchronous and asynchronous technologies (Leidner & Jarvenpaa, 1995). Employed in traditional, distance, and hybrid learning environments, a particular technology will affect learning interaction as determined by its capabilities and the degree of usage by learners and instructors.

Learning Model

Various taxonomies of learning models (Leidner & Jarvenpaa, 1995) and related teaching models (Joyce & Weil, 1996) provide a basis for differentiating learning models by their theoretical roots. These are the basis for the detailed design of instructional technologies. Teaching models have been classified as behavioral, social, information processing, and personal (Joyce & Weil, 1996) and are derived from educational theories such as objectivism and constructivism (Leidner & Jarvenpaa, 1995). While it has been proposed within much of the educational technology research literature that certain technologies such as CBT (computer based training) and CMC (computer mediated communication) are better suited to classes of learning models derived from objectivist and constructivist philosophy, there is not yet a body of research to substantiate these propositions (Hannafin et al., 1996).

Dimensions of Learning Interaction

An issue concerning learning interaction is its dimensionality. Many studies treat learning interaction as a one-dimensional construct, while others treat it as a multidimensional construct (Boak & Kirby, 1989; Haseman, Polatoglu, & Ramamurthy, 2002). A taxonomy of learning interaction for evaluation and research synthesizes the literature into six dimensions: amount, type, timeliness, method, spontaneity, and quality (Main & Riise, 1995). This taxonomy highlights quality as an important dimension of learning interaction, which can be further subdivided into the dimensions of intensity, relevance, formality, and opportunity. This taxonomy, as presented, however, has not been evaluated empirically in past research but is in this paper.

Measuring Learning Interaction

One approach to examining learning interaction is to measure learner perceptions. Perceptions of both personal and overall interaction, measured as single variables through self-reported survey, have been positively associated with learner satisfaction in studies of interactive television (Fulford & Zhang, 1993). These measures support the efficacy of perceived learning interaction. However, by concentrating on only two types of learning interaction, student-instructor and student-peer, the measure does not fully address other dimensions of learning interaction. This research advances measurement of perceived interaction (Fulford & Zhang, 1993) by integrating additional dimensions of learning interaction related to the interaction between the student and technology (Main & Riise, 1995) into the design of a more comprehensive instrument for this variable. A multi-item instrument, using Likert scales, was developed that asked students to rate their perceptions of interaction as derived from the literature.

Learning Outcome

Considered the most important variable in learning research (Jonassen & Grabrowski, 1993), learning outcome is an assessment of how well the learner achieved the learning objective. The learning outcome may be assessed using objective measures of cognitive abilities (pretest and posttest) as well as subjective measures based on student's perceptions. Both methods have been used in research on technology and learning. Two lower levels of knowledge (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956) were measured using pretest-posttest differences in this study. Student perceived learning outcomes were measured through existing multi-item scales of self-reported learning and class evaluation (Alavi, 1994).

Research Design

Method

A laboratory experiment with 18 treatment groups (332 students) was conducted in the context of an undergraduate introductory information systems course. A standardized instructional block on Visual Basic was the learning task for all groups. Conducted during two 2-hour laboratory sessions, the learning objectives measured included both declarative knowledge and procedural knowledge. An anonymous two-part survey included a pretest, perceptional measures of learning interaction, self-reported learning, class evaluation, and a posttest.

Experimental Design

A combination of three delivery mechanisms and two learning models formed six treatments. Technologies selected included Visual Basic for Applications plus: a Visual Basic software demonstration supporting instructor lecture, PowerPoint supporting instructor lecture, and a commercial CBT program delivered via the Internet with instructors facilitating usage. The two teaching models employed were direct instruction using active learning (individual learners) and cooperative instruction using active learning (paired learners) (Joyce & Weil, 1996). The design treated instructors as a random factor.

Analysis and Discussion

The data collected was first analyzed to determine the consistency of factors identified through factor analysis. These factors were used to create a set of variables measured as summated multi-item scales. The summated scales were then used in a correlation analysis of the various dimensions of learning interaction to assess their effect on perceived and objective measures of learning outcomes (posttest-prettest differences, self-reported learning, and class evaluation).

Dimensions of Learning Interaction

A principle components factor analysis of learning interaction survey items yielded eight factors (having Eignevalues in excess of 1.0). These factors corresponded to seven dimensions of learning interaction: student-instructor, student-peer, student-computer, relevance, formality, opportunity, spontaneity, plus an additional unexpected dimension, task specific interaction (Table 2). The data was consistent with major dimensions of interaction in the literature such as instructor and student-peer (Moore, 1990) as well as some dimensions of the taxonomy of learning interaction (Main & Riise, 1995).

The factor loadings were analyzed for discriminate validity by evaluating cross loading items. After eliminating items that did not load and cross-loaded items, each item was evaluated for its ability to discriminate one factor from another. Twenty-six items were retained that discriminated between the factors (Table 2). The reliability of items identified from the underlying theory and factor analysis was evaluated with Cronbach alpha values ranging from .647 to .776 (Table 2, last row). Given the exploratory nature of the analysis, these items were deemed acceptable for further analysis.

Effect of Learning Interaction on Learning Outcomes

A correlation analysis was conducted to determine the effect of each dimension of learning interaction on 3 measures of learning outcome. The first measure of learning outcome was the result of a fourteen item test that students took before and after the various treatments. Posttest minus pretest difference scores were computed for each individual. Self-reported learning and class evaluation measures derived from existing multi-item scales (Alavi, 1994). These outcome measures were compared to the various dimensions of learning interaction identified in the factor analysis using the Pearson correlation method.

Objective Measure Results

Three of the eight dimensions of learning interaction examined (formality, opportunity, and spontaneity) did not have a significant correlation with the posttest-pretest score in this study. The other five dimensions did have significant correlations with posttest-pretest measure. However, the direction of correlation was not consistent among the dimensions of learning interaction.

Relevance, student-computer, and task specific learning interaction all exhibited a highly significant positive association with the learning outcome variable. Relevance of interaction had a correlation of 0.215 (p-value <.0001), the largest correlation measured. Student-computer interaction had a correlation of 0.154 (p-value .004) and task specific learning interaction had a correlation of 0.138 (p-value .0025).

Student-instructor and student-peer interaction both had a highly significant negative correlation with the posttest-pretest learning outcome measure. The correlation of student-instructor interaction with posttest-pretest scores was -.218 (p-value <.0001). Student-peer interaction had a correlation with the posttest-pretest measure of -.135 (p-value .013). Interaction that was on task, considered relevant, and with the computer (on a programming task) leads to increased learning. Interaction with the instructor and other students did not lead to increase learning. This may indicate that students lacking understanding seek help or may be an indicator of trade-offs among the various dimensions of interaction. Either way this is an area in need of more research.

Perceived Measure Results

Self-reported learning on the other hand was significantly correlated with 7 of the 8 measures of perceived learning interaction (spontaneity p-value .06). Class evaluation was significant and positive for all 8 measures of learning interaction. There was a positive association for all measures, including student-instructor and student-peer, which were negatively associated with the objective measure. More research should also be directed at the inconsistency observed in the correlations of perceived learning interaction and objective measures and perceived measures.

Conclusion

The data strongly suggest that perceived learning interaction is a multi-dimensional construct whose components should be considered as individually influencing rather than having a monolithic impact on learning environments and outcomes. The factor analysis closely parallels taxonomies in the literature (Moore, 1990; Main & Riise, 1995) and adds empirical support for use of multiple dimensions when analyzing learning interaction. The notion that increasing learning interaction will always improve learning does not necessarily hold. This research and particularly the mixed directionally of effects on objective measures clearly points to a need to better understand the various dimensions of learning interaction. A method for comparing perceptual measures of learning interaction with objective measures needs to be developed. By understanding the learning process and how it affects learning outcomes educators, trainers, and researchers can determine how various combinations of teaching models and emerging information technologies may best be employed.

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Table 1. Correlation of learning interaction dimensions and learning outcomes.

Interaction Dimension \ Outcomes Pearson Correlation Coefficients Prob > |r| under H0: n=332	**Posttest – Pretest difference**	**Self-reported learning**	**Class evaluation**
Student-instructor interaction	-0.21876 <.0001	0.24143 <.0001	0.37359 <.0001
Student-computer interaction	0.15289 0.0052	0.48377 <.0001	0.34236 <.0001
Student-peer interaction	-0.13549 0.0135	0.11347 0.0391	0.26276 <.0001
Formality of interaction	-0.00982 0.8586	0.24995 <.0001	0.19295 0.0004
Timely opportunity of interaction	0.07222 0.1893	0.51442 <.0001	0.52019 <.0001
Relevance of interaction	0.21491 <.0001	0.42566 <.0001	0.27730 <.0001
Spontaneity of interaction	-0.04167 0.4492	0.10351 0.0600	0.14380 0.0088
Task interaction	0.13852 0.0025	0.46660 0.0115	0.31932 <.0001

Table 2. Items measuring learning interaction dimensions, factor loading, and reliability (Cronbach alpha)

Likert Scale: Strongly agree – disagree / Constant – Never **Reverse scored items adjusted for consistency in analysis.**	***Relevance of IA***	***Student Peer IA***	***Formal-ity of IA***	***Opportun-ity for IA***	***Computer task IA***	***Spontan-eity IA***	***On-task IA***	***Student Instructor IA***
I frequently interacted with the instructor during the Visual Basic class.	0.11336	0.11705	0.20384	0.13298	0.02791	0.06406	0.12771	**0.78417**
I frequently interacted with the other students during the Visual Basic class.	0.02010	**0.83642**	0.07977	0.09876	0.06744	-0.00599	0.09759	0.15274
I frequently interacted with the computer during the Visual Basic class.	0.09762	0.07451	0.02270	0.19352	**0.78899**	0.00094	0.05932	0.09996
The time spent interacting with the instructor during the class was constant	-0.03763	0.17729	0.13102	0.11033	0.15969	0.05920	-0.00974	**0.75574**
The time spent interacting with other students during the class was constant	-0.06791	**0.87988**	0.02211	0.04425	0.09310	0.04019	-0.04541	0.07292
The time spent interacting with the computer during the class was generally constant	0.03985	0.06071	0.14693	0.09458	**0.82595**	-0.00799	0.04356	0.03139
I was required to interact with the instructor during the class.	-0.07833	0.20630	0.10866	0.10678	-0.03950	0.23743	-0.09268	**0.58919**
I was required to interact with the computer during the class	0.12041	0.11400	0.14946	0.12826	**0.70192**	0.06659	0.23041	0.03763
I was required to interact with other students during the class.	0.04161	**0.63859**	0.11842	0.01255	0.02695	0.35439	0.10558	0.15193
Interactions with other students were mainly planned.	-0.01336	0.17788	-0.00065	0.04410	-0.02891	**0.87958**	-0.05927	0.06828
Overall, interactions were mainly planned.	-0.00912	-0.05639	0.15978	0.09308	0.05413	**0.85713**	0.05463	0.07091
Interactions were academically related.	0.03706	-0.16212	0.27218	0.25553	0.05268	-0.04728	**0.56753**	0.16854
Interactions during the class session were about the Visual Basic instruction.	0.17184	0.01754	0.19180	0.10124	0.29138	-0.04241	**0.65246**	-0.04355
Interactions during the class session were on personal or non-classroom related topics.	**0.40087**	-0.20954	0.12846	-0.02837	0.26872	-0.17646	0.14025	-0.07186
My interactions with the computer during class were mainly relevant.	**0.36182**	0.04838	0.17117	0.21249	0.18226	-0.02667	**0.58050**	-0.06730
My interactions with other students during class were mainly relevant.	0.30223	0.21127	0.13290	0.17350	0.01398	0.02584	**0.65007**	0.14471
My interactions with the instructor during class were mainly irrelevant.	**0.74548**	-0.07862	-0.02970	-0.03414	0.13801	-0.05673	0.15382	0.12390
Overall, my interactions were irrelevant.	**0.83662**	0.03321	0.00909	0.10012	0.05586	0.02027	0.14546	-0.01852
My interactions with other students during class were mainly informal.	0.26648	-0.07917	**0.37122**	0.07047	-0.13980	-0.16824	-0.45263	0.01694
My interactions with the instructor during class were mainly formal.	0.06352	0.12328	**0.81052**	0.04546	0.10040	0.06336	0.07443	0.18632
My interactions with the computer during class were mainly formal	-0.01809	0.02195	**0.85275**	0.04572	0.10796	0.06519	0.13999	0.06030
Overall, my interactions were formal.	-0.01134	0.03578	**0.89257**	0.09472	0.06330	0.06535	0.04775	0.08265
I had ample opportunity to interact with the instructor.	0.10346	-0.07733	0.09035	**0.75421**	0.10498	0.03573	-0.05673	0.27410
I did not have ample opportunity to interact with the computer.	0.40614	-0.07671	0.04343	**0.38257**	0.09976	0.14827	-0.15044	-0.21226
I had ample opportunity to interact with other students.	-0.01700	0.25066	0.03451	**0.77874**	0.03454	0.08625	0.26835	-0.02834
Overall, I had ample opportunities to interact during the class.	0.04420	0.04165	0.09777	**0.84761**	0.21912	0.05751	0.11298	0.09765
Factor loadings in Bold **Cronbach alpha:**	**0.647**	**0.776**	**0.742**	**0.697**	**0.759**	**0.770**	**0.722**	**0.682**