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ABSTRACT

Interaction research in distance education has focused mostly on learner-teacher interaction in a learning environment based on a behaviorist curriculum. This study examines interaction patterns at both interpersonal and system levels in a learner-centered distance collaborative learning environment. The proposed model, which resulted from research on patterns of learner interaction in both the synchronous and asynchronous computer-mediated communication modes, examines factors contributing to interaction in the areas of learner characteristics, technology attributes, and learning activities. At the system level, student perceptions of both synchronous and asynchronous computer-mediated communication (CMC) systems and the relationship with interaction are investigated. At the interpersonal level, patterns of learner-learner interaction over both communication modes are compared and contrasted. The overall effects of various theoretical-based instructional activities on learner interaction are also scrutinized. The research methods include content analysis, formative and summative evaluation of the instructional activities, and technologies employed in a distance-learning course. The data for content analysis are based on conference transcripts from both synchronous and asynchronous communication. Formative data are based on student reflection journals, instructor's log, and observers' logs. (Contains 13 references.) (AEF)

Model of Learner-Centered Computer-Mediated Interaction for Collaborative Distance Learning

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Abstract

Interaction research in distance education has focused mostly on learner-teacher interaction in a learning environment based on a behaviorist curriculum. This presentation focuses on factors contributing to learner-learner interaction in a distance learning course based on learner-centered and collaborative instructional design. The proposed model, which resulted from research on patterns of learner interaction in both synchronous and asynchronous computer-mediated communication modes, examines factors contributing to interaction in the areas of learner characteristics, technology attributes, and learning activities.

Introduction

Interaction research provides important information on student behaviors in distance learning environments to educators, researchers, and instructional designers. The current state of interaction research has focused mostly on the quantitative results of inter-connected messages in computer-mediated communication (CMC) conferences. Contributing factors to interaction such as theoretical principles of course design and learning contexts are largely ignored. While various virtual learning environments and course management systems are being introduced to the distance learning community, it is easy to loose sight on the pedagogical application of the learning systems. Teachers are rushed to learn various state-of-art instructional technologies but not given instructional examples or time to develop well-designed instructional materials for conducting distance learning courses. The issues faced by the educators are similar to that of a novice pilot being rushed to drive a commercial airplane without going through appropriate training via flight simulation. More research on how these systems can enhance student learning and examples of best practices on instructional design in various disciplines are needed for the success of distance education. As interaction has been identified as the key to the success of online learning by researchers (Gunawardena et al., 1997), this study examines patterns of online interaction and the types of instructional design that would enhance online interaction via both synchronous and asynchronous communication.

Learner-centered computer-mediated interaction in this study is defined as reciprocal communication among participants of computer-mediated learning environments that emphasizes learner developments in cognition, motivation, and social advancement for the purpose of knowledge construction and community building. Two theoretical principles that are highly relevant to such interaction are constructivism and learner-centered principles (LCPs). A constructivist distance learning environment places emphases on knowledge construction through interaction with the physical environment and through the appropriation of culturally relevant activities. In other words, knowledge is co-constructed with peers or experts and through the immersion in a social context (Bonk & Cunningham, 1998). The Learner-Centered Principles were developed by the American Psychological Association (APA, 1997) as a framework for the new educational approaches that stress the integration of the needs, skills, interests, and backgrounds of the students into the curriculum planing. The following section on literature review examines the connection between these principles and interaction.

Literature Review

Interaction is often emphasized in different contexts for different purposes, such as construction of knowledge (Gunawardena et al., 1997), and student satisfaction (Hackman and Walker, 1990). Moore (1989) contributed to the discussion of interaction by providing an important framework of three types of interaction: learner-content, learner-instructor, and learner-learner interaction. Moore pointed out that learner-content interaction is a "defining characteristics of education." As a result of learner-content interaction, learners achieve intellectual growth or changes in perspectives. The second type, learner-instructor interaction, highlights the important role of instructors. In addition to defining the learning objectives, activities, and materials, distance instructors are also responsible for revising teaching methods and providing evaluation as their students progress in the process of learning. The third type, learner-learner interaction, takes place between learner and other learners in real-time or delayed time and is not restricted to the presence of the instructor. This "inter-learner interaction" can foster learning through student collaboration and knowledge sharing. Although the strategies used to increase learner-learner interaction vary according to the characteristics and backgrounds of the learners, learner-learner interaction can significantly encourage the development of student expertise in different subject areas and promote community building.

Hillman et al. (1994) added a fourth component on learner-interface interaction to the literature discussion. They defined learner-interface interaction as "a process of manipulating tools to accomplish a task" (p. 34). They stressed the importance of learner-interface interaction because the "learner must interact with the technological medium in order to interact with the content, instructor, or other learners" (p. 33). The learner must be empowered to profess the necessary skills to use the communication tools and feel comfortable with the learning environment. Good interface design can enhance interactivity and minimize technological barriers to online learning.

These definitions also highlight the importance of the interrelationship among learners, content, and technology. In the design of a learner-centered distance learning course, it is important to include the four types of interaction in the design. Furthermore, learner-centered principles also provide "an essential framework to be incorporated in new designs for curriculum and instruction, and assessment systems for evaluating educational goal attainments" (American Psychological Association, 1997, p. 1). LCPs consists of the following areas of learning: cognitive and metacognitive factors, motivational and affective factors, developmental and social factors, and individual differences.

As pointed out by Wagner and McCombs (1995), these principles emerged from the following considerations:

- Learners operate holistically as a function of intellectual, emotional, social and physical characteristics.
- The learner's behavior is based on his or her perceptions and evaluations of situations and events from a self-orientation that interprets meaning and value relevant to personal goals and interests.
- The learner's development across all domains of functioning is never static and unchanging, but is a dynamic growth process that serves inherent needs for mastery, control and belonging. (p. 34)

In the context of distance education, the infusion of LCPs into the design of learning systems and instructional activities has provided enhanced opportunities for educators to improve teaching/learning activities. Traditionally, teachers decide what the learners need to know by devising the objectives, instruction, procedures, curriculum, materials, and evaluation. Recently, the increased discussions on learner-centered education have led more educators to recognize the values of empowering the students to take control of their learning. The design of the curriculum takes into consideration students' background and prior knowledge in the subject matter.

The LCPs provide a solid framework for the new educational approaches. However, the actual implementation is subject to individual interpretation and still requires much effort for educators to come up with feasible strategies. Fortunately, constructivism that originates from philosophical and educational theories has provided viable strategies for teaching and learning. Jonassen et al. (1995), long-time advocates of constructivism for CMC systems in distance education, argued:

> Constructivist principles provide a set of guiding principles to help designers and teachers create learner-centered, collaborative environments that support reflective and experiential processes. Students and instructors can then build meaning, understanding, and relevant practice together and go far beyond the mere movement of information from instructors' minds to students' notebooks. (p. 8)

According to Jonassen et al. (1995), the four constructivist attributes for building learning systems are context, construction, collaboration, and conversation. *Context* refers to the "real world" scenario in which learners can carry out learning tasks as close to the real world as possible. Learning tasks should have real-world implications so that learners can connect what they learn in the classroom with the real world. *Construction* concerns knowledge that is built on the "active process of articulation and reflection within a context" (Jonassen, 1995, p. 8). Learners acquire knowledge better when they can link their own experience with the learning materials and make sense of them. Learners master a subject better in the process of constructing knowledge. *Collaboration* helps learners to develop, test, and evaluate their ideas with peers. Learners are exposed to multiple perspectives in a problem-solving case and then come to a self-selected conclusion on a particular issue. This is an important part of the learning process. *Conversation* is engaged by group members for purposes such as planning, collaboration, and meaning making. It is especially important for distance learning because most communication is done through online exchanges. A successful conversation will lead to good preparations for and completion of online tasks (Jonassen et al., 1995).

Distance learning courses that are based on the LCPs and constructivism have demonstrated enhanced interaction and academic achievements. The next section reviews the process of implementing the theoretical principles into the instructional design of a distance learning course.

Background

The course for this research is an upper level undergraduate course titled "Theories and Applications of Computer-Mediated Communication Systems" offered at the University of Hawaii. The main objective of the course is to enrich the understanding of CMC systems through discussions and effective use of various CMC systems. The course design is based on the following theoretical principles:

Principle 1: Learner-centered instructional design: The course design considers student development, especially in the following areas: cognitive, meta-cognitive, motivational, affective, social, and individual differences. Students learn to monitor their own progress, manage the course content, and develop expertise in a sub-domain of CMC study. Specific examples of learner-centered instructional activities include the use of student reflection journals for the purpose of metacognition and student-centered discussion for motivating them to take control of the subject matter.

Principle 2: Constructivist activities: The emphasis is placed on student acquisition of knowledge via active involvement with the curriculum rather than via imitation or memorization of facts or course content. Specific instructional activities based on the constructivist principles include synchronous and asynchronous discussions for co-construction of knowledge and project-based learning for real-world application.

Principle 3: Small group cooperative learning: Students collaborate on tasks in small groups to accomplish a set of predefined learning objectives and to advance their knowledge in a domain. Emphases are placed on community building and knowledge sharing. They equally share the responsibilities of the assigned tasks and semester projects. At the end of each term, they demonstrate the ability to accomplish the task on an individual base.

The course for this study was conducted through a number of text-based (WebCT chat and ICQ), audio-video conferencing (CU-Seeme & Netscape Cooltalk), and enhanced virtual systems (The Palace & Active World). Students took turns to moderate seminars in three-member small groups each week. They followed the guidelines of Student-Centered Discussions (SCD) (Chou,

1999; Shooop, 1997) to participate in the online seminars. In general, students participated each online seminar by following the SCD principles such as respecting each other, generating ideas, listening tentatively, and referencing each other during conversation. Whereas, student moderators kept the discussion alive by observing rules such as greeting participants, devising warm-up activities, making an opening statement, using a step-by-step discussion process, asking questions, scripting the discussion, and preparing concluding remarks (Chou, 1999), Detailed description of instructional design, course syllabus, and the CMC systems employed are described in the research by Chou (2001a, 2001b)

Research Design and Methods

This study examines interaction patterns at both interpersonal and system levels in a learner-centered distance collaborative learning environment. The research focuses on factors that affect interaction from three areas: learning activities, technology attributes, and learner characteristics. At the system level, student perceptions of both synchronous and asynchronous CMC systems and the relationship with interaction are investigated. At the interpersonal level, patterns of learner-learner interaction over both communication modes are compared and contrasted. Furthermore, the overall effects of various theoretical-based instructional activities on learner interaction are also scrutinized. The research methods include content analysis, formative and summative evaluation of the instructional activities, and technologies employed in a distance-learning course. The data for content analysis are based on conference transcripts from both synchronous and asynchronous communication. Formative data are based on student reflection journals, instructor's log, and observers' logs. Four observers were invited to observe the class on a weekly basis. They submitted a weekly log to the instructor to suggest improvement on the instructional design and activities for this class. The summative data are collected from the following student surveys: student background, course evaluation, CMC-skill assessment, student perceptions of communication characteristics of technology, group cohesiveness and performance. Detailed descriptions of these surveys can be found in Chou's dissertation work (2001b).

Both synchronous and asynchronous seminars were conducted on a weekly basis. In the synchronous seminar, students were responsible to take turns in moderating small group discussions. In the asynchronous seminar, students collaborated in building a knowledge base by sharing and exchanging constructive views on a topic related to CMC systems. In addition to the weekly discussion, the semester-long projects also required the students to collaborate in small groups via various CMC systems.

Bale's (1950) Interaction Process Analysis (IPA) was adapted as the basis for content analysis to describe the patterns of student interaction in small groups via both synchronous and asynchronous networks. IPA was originally developed to study small group interaction in two main areas: socioemotional -oriented and task-oriented interaction.

Research questions are divided into the following three main categories:

A. Technology Attributes

QA1: What are the technological factors that affect student interaction?

B. Learning Activities

Synchronous vs. Asynchronous discussions

QB1: Is there a significant difference in the social-emotional contents and task-oriented contents between synchronous and asynchronous communication?

Conference Moderation

QB2: Moderator vs. Participants: How can a conference moderator help to facilitate online discussions?

Small Group Collaboration

QB3: What are the student perceptions of small group collaborative activities?

C. Learner Characteristics

Prior Computer experience

QC1: Is learner's experience with computer correlated with total number of messages submitted?

Gender

QC2: Is there a significant difference in the SE-oriented vs. task-oriented contents between female and male participants?

Analysis and Discussion

Technology Attributes

Students rated each CMC system on the following communication characteristics: social presence, communication effectiveness, and communication interface. Of all systems tested, WebCT chat received the highest rating and the Palace came in second place. This is an indication that students valued reliable and smooth connection for communication. WebCT chat turned out to be the most reliable and straightforward CMC systems used. In addition, the add-on affective components (wearable-avatars, voice-activation, bubble messages, etc.) in the Palace actually made the conversation more realistic. Students demonstrated enjoyment in using the avatars to express themselves during the online conversations.

Positive technological attributes can enhance interaction and negative technological attributes can hinder interaction. Table 1 is a summary of various technological factors that affect interaction.

Table 1. Positive and Negative Technological Attributes Affecting the Degree of Interaction

Positive Features	Negative Features
A. System performance	
Fast loading, low bandwidth	Bandwidth intensive
Transcript recording	Non-recordable conversation
Good audio/video quality	Poor audio/video quality
Cross-platform compatibility	Platform-specific
B. Interface design	
User-friendly navigation tools	Nontransparent or no navigation tools
Learner centered (e.g., customizable, flexible, and scalable interface)	Program controlled (e.g., fixed and un-customizable interface)
Wearable avatars with a variety of selections	Fixed-type avatars with stereotypical selections
Low levels of distraction (e.g., good visualization of screen icons)	High-levels of distraction (e.g., lack of organization of screen icons)
Status indication (e.g., occupied, off-line, online, etc.)	Lack of status indication
Accessible to users with disabilities (e.g., Bobby-approved, text-to-speech option)	Not accessible to users with disabilities
C. Communication characteristics	
High degree of social presence	Low degree of social presence
Effective for communication at interpersonal level	Ineffective for communication at interpersonal level
Effective for communication at system level (e.g., fast message exchanges)	Ineffective for communication at system level (e.g., delayed message exchanges)
High degree of expressiveness (e.g., mood indicators)	Low degree of expressiveness
Affective communication components (e.g., optional toolbox for emoticons, props for avatars, etc)	Impersonal communication components (e.g., command-line oriented communication)
Division of public vs. private space (e.g., breakout sessions for small groups)	Lack of division of meeting rooms

Based on the observation by the instructor and evaluators, student adaptation to technology can be summarized in four stages:

- The WOW stage: At the initial phase, students were fascinated with the potential of technology and amazed at what CMC systems could have accomplished.
- The FUN stage: At the second phase, students actually used the systems for simple tasks and derived a great deal of pleasure in the hands-on experience.
- The OH-OH stage: This was the frustrating stage when more complex tasks were given and their skills had not developed enough to handle these tasks.
- The "Back-to-Normal" stage: Students either became more competent in the use of technology or became comfortable with dealing with technical difficulties. They internalized their anxiety and accepted that technical glitches were inevitable in the learning process.

Learning Activities

a. Synchronous vs. asynchronous discussion

The two main categories in Bale's IPA are social-emotional oriented interaction and task-oriented interaction. The multiple regression analysis shows that both variables significantly predict the interaction patterns in both communication modes, $F(2, 116) = 85.7$, $p < .0001$ (Table 2). The mean sentence per person in synchronous mode is 26.31 sentences and 51 sentences in asynchronous mode. Because $R = .77$ and $R^2 = 0.6$, 60% of the variance is accounted for by these independent variables. The analysis shows that there is a significantly higher amount of SE-oriented interaction in synchronous discussions and a significantly higher volume of task-oriented interaction in asynchronous discussions.

Table 2: Multiple Regression Analysis Predicting Interaction in Synchronous Versus Asynchronous Discussions

	Syn. Mean	*Syn. SD*	*Asyn.Mean*	*Asyn. SD*	*F*	
SE	8.66	8.12	4.26	4.72	-7.46	***
TASK	17.65	15.53	46.74	19.11	12.21	***
totals	26.31	22.01	51.00	20.76	5.85	***

***$P < .0001$

In the synchronous communication mode, there was more spontaneous communication going back and forth. The communication processes between asking and answering questions are more equally distributed in synchronous communication, whereas in asynchronous communication, students tended to volunteer to give more information than to ask questions.

The synchronous communication mode also made it easier to provide immediate feedback to information seekers. Some students were actively engaged in discussions while other students waited until they were asked to say something. The researcher observed that there was more equal participation in the discussions in three-member small groups than in large groups. In addition, in synchronous mode, participants asked more personal questions and revealed more about their frustration or need for help with less hesitation. Personal questions such as one's occupation, schooling history, and background of technical training were included more often in synchronous discussions.

b. Conference moderation

Students took turns moderating small group discussions in the weekly synchronous seminars. Every group was responsible for hosting one online seminar in the semester. Because there were thee members in each group, the seminar was usually divided into three small groups so that each member of the host group could moderate one group in the online seminar. The moderator's action is highly correlated with the performance of the conference participants. According to Table 3, when a moderator sent out more task-oriented content, the participants also responded with more task-oriented messages, $F(1, 163) = 36.58$, $p < .0001$. Likewise, when a moderator sent out more SE-oriented content, the participants responded with messages of the same nature, $F(1, 163) = 11.91$, $p < .001$. In addition, the total number of messages sent by the moderators also contributed positively to the total number of messages sent by the participants, $F(1, 163) = 28.85$, $p < .0001$. Overall, the moderator's functions are vital to the information exchanges in a small group discussion. The comparison of the mean sentences between moderator and participant indicates that in order to encourage active discussion, the moderator usually sent out two or three times more sentences than the participant.

Table 3: One-Way ANOVA Between the Mean Sentences Sent by Moderators and Participants

	Moderators	*Participants*	*F*	
SE Mean	9.05	3.5	11.91	**
Task Mean	24.15	6.29	36.58	***
Total Mean	33.19	9.78	28.85	***

$^{***}p < .0001$, $^{**}p < .001$

c. Small group collaboration

Two forms of collaboration took place in small groups: synchronous seminar and project preparations. In addition to working together to host a successful synchronous seminar, members of a small group also met several times in private throughout the semester to prepare for seminar moderation and case study. Students were asked to complete the questionnaires on group cohesiveness, individual commitment, and individual performance at the end of the term. The highest score one member of a group could get was 40 points. In Table 4, the mean score of each group is listed.

Table 4 Group Performance Evaluation and Group Cohesiveness Score

Groups (n = 3)	Cohesiveness		Perceived quality of group performance	
	Mean	SD	Mean	SD
GROUP 1	39.67	0.82	5.98	0.86
GROUP 2	37.5	3.89	6.02	1.16
GROUP 3	38.5	2.07	5.94	0.97
GROUP 4	32.5	10.61	3.76	1.63
GROUP 5	37.0	4.08	5.53	1.18

The correlation between the perceived quality of group performance and group cohesiveness is significantly high, $r = .95$, $p = .01$. Group members who rated their actions highly cohesive also deemed their performance high. However, the correlation between perceived quality of group performance and individual commitment is low, $r = -.12$, $p = .29$. Individuals who were committed to their work did not necessarily consider group performance quality high (see Table 5). In some instances, members of a group might work harder when they foresaw that the quality of group performance would not be up to standards. Putting students in small groups and assigning collaborative tasks to each group does not always guarantee a successful learning experience. The summary section concludes a number of factors affecting online interaction..

Table 5 Mean Score of Individual Commitment and Perceived Quality of Group Performance

Groups (n = 3)	Perceived quality of group performance	Individual Commitment
GROUP 1	5.98	5.83
GROUP 2	6.02	6.64
GROUP 3	5.94	5.50
GROUP 4	3.76	6.13
GROUP 5	5.53	6.00

Learner Characteristics

Due to insufficient data and small sample selection, no significant correlation was found between total messages sent by each participant and their previous computer experience. In terms of gender differences, significant differences were found in synchronous mode in both SE-oriented and task-oriented interaction. In general, female participants sent out more sentences than the male participants in both synchronous and asynchronous communication modes; the female mean sentences are higher. Nevertheless, female participants sent out significantly higher number of messages in both SE-oriented and task-oriented areas. Overall, female participants consistently sent more SE-oriented messages in both communication modes.

Summary

Interaction Factors

The main conclusion drawn from this study is that the design of learner-centered online activities and the selections of appropriate technologies do contribute to different patterns of interaction. The research findings are summarized as follows:

A. Learning activities: Constructivist-based instructional activities such as student-moderated discussion and small group cooperative learning are conducive to interaction and learning. Specific findings are listed as below:

a. The appropriate use of synchronous online seminar can enhance interpersonal relationship. In general, students submit a higher percentage of task-oriented messages than social-emotional oriented messages in both asynchronous and synchronous communication modes. Nevertheless, there is a higher percentage of social-emotional interactions in synchronous mode than in asynchronous mode.

b. Asynchronous peer review provides the opportunity for collaboration on building knowledge bases and information sharing.

c. Interestingly, there was more one-way communication in asynchronous mode. In asynchronous mode, students seemed to be more interested in expressing opinions than challenging each others' views; whereas in synchronous mode, there were more questions and answers. Students were more engaging in the synchronous discussions. There was a stronger sense of immediacy to respond to peers' questions in synchronous mode than in asynchronous mode.

d. Student-moderated conference based on the SCD Model allows learners to take initiatives in their learning and be efficient in communication via various CMC systems.

e. Forming small groups for online seminars or group projects helped to reduce the initial disorientation and confusions of online learners.

B. Technology attributes: Discussion on technology attributes focuses on the mode of communication systems and the communication characteristics such as social presence, communication effectiveness, and communication effectiveness.

a. Communication systems: the selections of synchronous or asynchronous technologies contributed to the different interaction patterns. Students tended to spend much more time in task-oriented discussions in asynchronous mode. When online tasks were clearly defined and students passed the initial "get-to-know-each-other" stage, students were inclined to spend less time in SE-oriented interactions in both communication modes. Nevertheless, learners consistently spent more time in SE-oriented interaction in synchronous mode than in asynchronous mode.

b. Communication characteristics: Student ratings of a CMC system increased as the frequency of uses increased. Student perceptions of the communication characteristics of technologies might affect their initial interaction online. Time played an important role in student adoption of new technology. Usually after the first two or three weeks, students were able to ignore some of the "obstacles" of a system and concentrated on the task at hand.

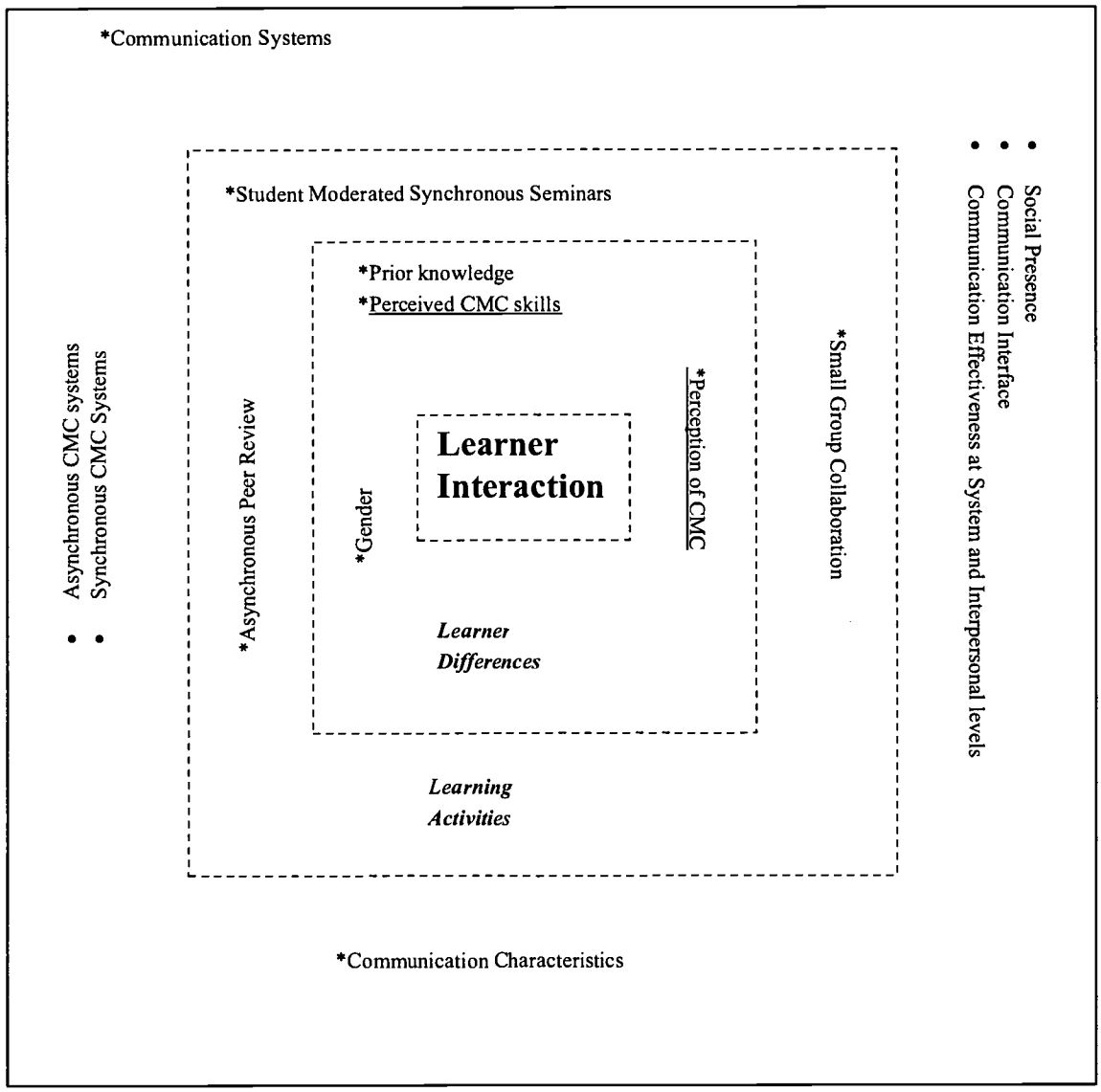
c. Learner characteristics: Gender difference affects how students interact online. Female students contributed more to SE-oriented interaction than the male students in both communication modes. In addition, prior knowledge in a subject matter and computer experience contributed to the different interaction patterns in the individuals at the beginning stage. After the first two weeks, the difference was hardly noticeable.

As the result of the research, a model of Learner-Centered Computer-Mediated Interaction for Collaborative Distance Learning is proposed to explain factors that could affect interaction as shown in Figure 1.

Conclusions

Research in distance education covers a wide spectrum of issues. Although interaction is not the only key to successful distance education, this factor is vital to the progress of learners, teachers, and the school as a whole. As Gunawardena et al. (1997) has boldly put it: "No interaction, no education." This research emphasizes the importance of interaction research by providing supporting evidence in activity design, technology employed, and learner differences. This study advocates the integration of learner-centered instructional design and constructivism into the curriculum. The researcher hopes to break the myth that synchronous communication is impossible to manage. On the contrary, as shown in this study, the appropriate incorporation of synchronous activities can enhance learning interests and interpersonal relationship. Although there is no lack of research in distance education since the 1980s, there is a need for more research on emerging technology employed in distance education because the implications and applications also affect educational policy and management. This study is a small contribution to the understanding of the ever-changing technological ecology of distance education.

Figure 1: Model of Learner-Centered Computer-Mediated Interaction for Collaborative Learning



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