The Development of an Interaction Support System for International Distance Education

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Abstract—This paper reports on the implementation of a learner identification system developed to facilitate real-time interaction in an international distance course. To increase the teacher immediacy and social presence, it proposes an integrative system for incorporating technology to improve the learning involvement, teaching effectiveness, and quality of interaction in the context of distance education. After the system was implemented in a formal international distance course involving universities in Japan and Taiwan for a semester, the results of the formative evaluation suggested that a perceived integrative classroom environment was achieved. The instructors and learners agreed that the system effectively and seamlessly integrated synchronous and asynchronous learning through the computing components of face and speech recognition. It was also found that the improved interaction led to a better sense of learning community and improved performance. This study concludes that the system could be useful in improving interactions and reducing students' feelings of isolation in distance courses by increasing their social presence. Suggestions for future studies and system development are also provided.

Index Terms—Distance learning, face and gesture recognition, synchronous interaction, videoconferencing

1 Introduction

In the past decade, the proportion of international distance learners participating in higher education has increased exponentially in Europe, Asia, and other developed nations, increasing awareness of the international dimension of higher education [1], [2]. However, many students face a number of challenges that prevent them from learning at rates similar to those they could maintain with domestic instruction. According to these students, having conversations and discussions in distance classes can be stressful and difficult due to time pressures and the unfamiliar classroom environment. Previous studies in cross-cultural classrooms have suggested that student motivation and performance can be affected by cultural orientation, such as uncertainty avoidance and collectivism [3]. With respect to Brophy's conceptualization of student motivation [4], decreases in motivation toward learning were found in Japanese university students as compared to their counterparts in North America in a distance course [5]. These results are supported [6] and suggest that Japanese students remain silent in class in order to avoid confrontations with others and making mistakes [5], [6]. In terms of the state of motivation, which describes student attitude toward the specific distance classrooms, Japanese students tend to avoid interactions requiring a higher sense of social presence in distance classrooms due to growing uncertainty in unfamiliar technology-rich surroundings [5], [7]. The perceived alienation resulting from declining motivation has been found to decrease student participation in distance learning [8]. Considerable resources have been invested, and schools expect teachers to be active agents within the educational environment to stimulate student motivation. But distance educators may find it difficult to notice and respond to student interaction requests [9], as they have their hands full with manipulating and switching between different media, devices, and systems. This attenuated teacher immediacy is often associated with a decrease in student motivation and performance [7], [10]. Therefore, previous endeavors have attempted to facilitate teacher immediacy by improving teacher-student communication and interaction [11]. However, a systematic view of the distance classroom is required, and in previous distance education studies, there is still a lack of an integrative view to coordinate each part of the educational system [12].

Recently, computing and recognition technologies have been widely applied [13], [14]. The merits of using recognition technology to automatically collect data for further analysis are commonly recognized in research and practice. In addition, the focus of ubiquitous computing on the seamless integration of various technologies is consonant with the systematic view of distance education. Therefore, while tackling the interactivity problems in distance education, the present study also seeks to explore and verify a paradigm of ubiquitous computing that supports the application of sensing and recognition technologies in international distance classrooms to develop a seamlessly integrated distance learning experience. An interaction support system was developed and implemented in a formal international distance course for a semester involving two universities in Taiwan and Japan. This paper describes the design of the system, which integrated real-time recognition technologies and online learning logs to facilitate and support students' synchronous and asynchronous participation in distance education. This paper also reports the results of an evaluation of the system to portray how effectively context-aware technologies can support learning and assessment in distance education.

2 Background and Related Work

2.1 Interaction in Distance Education

Interactivity has long been important in determining the quality of classroom teaching and learning for both instructors and learners. While the size of a class, the facilities, and the environment influence student motivation at the beginning of the learning process, and hence affect the effectiveness and efficiency of instructional communication, managing interactivity in a large distance classroom is quite challenging for instructors of all levels. Previous endeavors have adopted a variety of technologies and strategies to improve the interactivity in distance educational contexts, including message boards [15], videoconferencing [16], [17], [18], and recent Web 2.0 tools such as blogs and wikis [19], [20]. However, most of the aforementioned applications focus on partially interactive activities in distance education at the risk of oversimplifying the realm of distance classrooms without considering the procedural and interactive artifacts generated in the distance-learning context. As suggested by social presence theory [21], for any communication in general, and for telecommunication in unfamiliar surroundings specifically, people rely on various cues to develop a sense of the importance of themselves and of others in order to proceed with their conversations or actions [3]. In a typical videoconference, these oral cues, including facial expressions, tones, and gestures, must be conveyed by camera. However, it could be tedious and time-consuming to operate the camera manually, and many of the conversational cues that people rely on in ordinary face-to-face communications can thus be lost [22], [23], [24]. This loss reduces the sense of presence in the context. In contrast to interactions in ordinary face-to-face classrooms, real time

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conversations in a videoconferencing context are not easy to conduct smoothly. During a videoconferencing call, each participant competes with others for limited video and audio resources, resulting in halts and turn-taking. Such interruptions lead to lagging and ineffective communication [25], [26]. Participating in such conversations is challenging and discouraging [27], and the consequent affective responses of the participants could gradually increase the perceived feelings of distance for both the instructors and the learners [11].

Moore [28] distinguished different types of interactions in distance education. Among them, synchronous interactions with human beings [29] such as student-student and student-teacher interactions are valued as the most determinative factors in satisfaction with distance courses [30]. Previous studies tackled the interaction problem by providing distance teachers and students with computer-mediated media and technologies. Videoconferencing, satellite broadcasting, and online tools record and convey visual and audio information across distances [31], [32], [33]. However, distance teachers who want to conduct an ordinary Q&A session in class might find themselves overwhelmed by the requirements of using multiple technologies [34], [35]. Most of the time, they need to wait until the camera view changes to find out which student is asking a question, and the students may also be frustrated by interacting with others in technology-enhanced environments [36], [37]. The incorporation of these technologies, though they successfully convey signals and symbols, ineffectively re-creates the phenomenon of human communication in class. In spite of the crucial role of technology in distance education, the redundant and discrete use of technologies can make interactions ineffective and inefficient.

2.2 Incorporation of Technology for Integrated Interaction Support

Ubiquitous computing involves multiple context-aware techniques, including sensing and recognition, in order to provide users with integrative and real-time support [38]. In the fields of entertainment, identification, and surveillance, applications based on recognition techniques are common [39]. Whether a human being is present can be effectively detected at a low computing cost by a feature-based method [40]. Further identification of the user can also be derived by image-based approaches such as skin-color and facial muscle model matching [41], [42]. In educational settings, such recognition could have great potential for autonomous camera management in support of synchronous interaction that preserves rich contextual clues such as the genders, positions, and names of the attendees.

Technologies for supporting synchronous interaction focus heavily on externalizing the interaction by simulating real-time conversational rules, such as delivering audio-visual information for responses. However, human communication often involves intellectual activities that occur both synchronously and asynchronously in class. For instance, a conversation can involve interactions among instructors' and students' previous or current experiences and knowledge [12]. To complement the abundance of studies focused on the effectiveness of individual tools or platforms in support of communication and interaction in distance education, more research efforts are required to examine the incorporation of multiple technologies with an integrated approach.

3 METHODOLOGY

3.1 Context of the Study

This study was conducted in a formal, multi-site, undergraduate-level international distance course. A team of five instructors from two universities in Taiwan and Japan co-taught a course in Educational Technology for a semester of 13 weeks. Every week in the class meeting, two instructors met with 18 students in a classroom in Taiwan, and three instructors met with 10 students in a classroom in Japan. The two classrooms were connected synchronously by videoconferencing, and English was the language spoken for course delivery and discussion. A blog-based course website, which served as the learning management system, archived the course materials and supported students' asynchronous learning activities such as group discussion and resource sharing. The curriculum of the international distance course used project-based learning as the framework to incorporate the instructional and learning activities. At the beginning of the semester, all the participants, including the instructors and students, were assigned a personal blog and required to introduce themselves to the class. Students were asked to form groups comprising members from both universities to collaboratively work online using their group blogs for the term projects, which focused on discovering the educational use of information and communication technology (ICT).

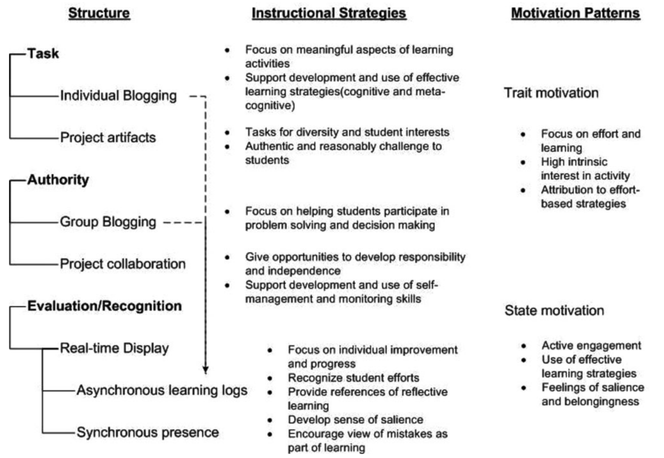

Fig. 1. Classroom structure of the distance course.

The development of the interaction support system was inspired by the instructional need to cope with the certainty-centric school cultures of Japan and Taiwan [3], [7]. In order to develop a set of immediacy behaviors that culture social presence in an international distance classroom, the instructors' use of technologies and the impact of those behaviors on students in synchronous and asynchronous communication were considered systematically. Fig. 1 shows the classroom structure with reference to the instructional strategies and motivational patterns pursued by the instructors.

3.2 Design of the Interaction Support System

This study employed an interdisciplinary design approach to coordinate the instructional, interactive, and technological components of international distance education. First, to convey signals to make a communicative context, the system integrated videoconferencing, due to human preferences for live interaction [43], [44]. Second, the cameras were automated to prevent interruptions or delays in the ongoing conversations. We used the natural conversational cues of speech, instead of manual judgments, to initiate the automated camera control. Third, face and speech information obtained by sensing and recognition engines was used to locate the students' previous learning artifacts by matching the information to their online learning logs. Finally, to associate the synchronous interaction with the asynchronous learning activities, all information was integratively displayed in real time in class for teachers and students to review. The architecture of the system is illustrated in Fig. 2.

Specifically, the system approached the problem of learning performance by tackling three major elements: the uncertainty

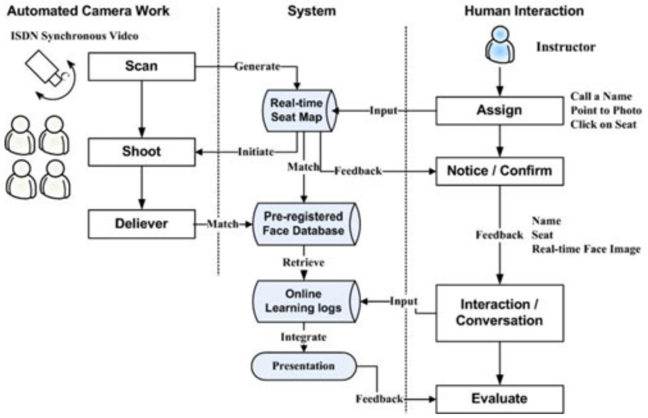

Fig. 2. The system architecture.

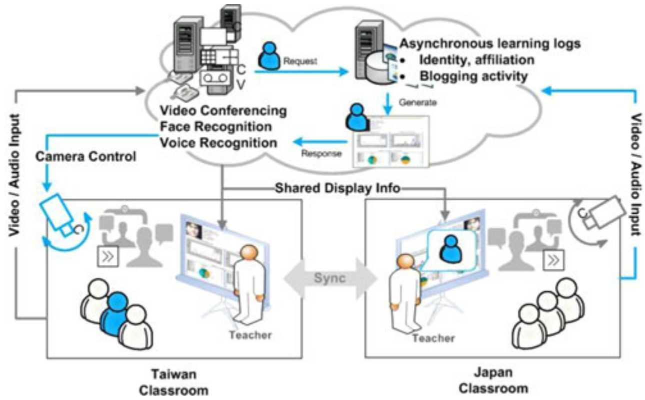

Fig. 3. Scenario of system application.

present in the situation, students' achievement-related motivation, and students' uncertainty orientation. In order to manage the uncertainty inherent in the situation, an integrative display was developed to show the ongoing activities in the physical space of the real-time classrooms, along with the accumulated learning progress in the virtual space. Due to considerations of learners' attention span [45] and motivation, only limited amounts of critical information were displayed. Identity information, including student names and photos, served as an instant prompt that visually and verbally described the students. Information on group and university affiliations facilitated the awareness of the community. In order to encourage effort-based learning strategies, learners' posting and commenting activities on their group blogs were summarized in line graphs for comparison with those of their peers in other groups. Reviewing the progress of their classmates and teamates allowed individual learners to reflect on their own performance and seek alternative learning strategies, by which they could enhance their achievement-related motivation. Last, to tackle students' uncertainty orientation and trait motivation, a system that supported the instructional emphasis on encouraging and recognizing effort-based learning strategies was employed. Individual and group blogs provided all students with the space to manage resources and their learning progress.

The system was built with the OKAO Vision Library for face recognition, the open-source large vocabulary CSR engine Julius for speech recognition, the JpGraph2.0 Library for learning profile visualization, and MySQL 4.1.11 for the database. The rate of accuracy of the face recognition and attendance estimation was an acceptable level of 0.8. Due to the structural and pronunciation interference of students' mother tongues, the rate of accuracy of speech recognition was lower, at 0.6. In order not to interfere with the real-time interaction in the educational experiment, manual confirmation by distance teachers was added to check whether the results of the speech recognition were acceptable before proceeding. The key feature of the interaction support system was that it synchronized the results of face recognition with the matched asynchronous learning profiles in real time, and made them available for instructors and students to retrieve in class.

3.3 Application Scenario

The data processing procedure involved learner identification by face recognition, camera control by speech recognition, and the visualization of interactions by integrated presentation of synchronous and asynchronous activities. The system algorithm for the automated camera functioned within the conversational scenario of calling a name, which served as a critical cue to initiate conversations occurring in large distance classrooms. When the teacher called a student's name, the system recognized and matched the name with the facial image to identify the seat of the student and then activated the camera to provide a portrait view of the student in real time. Finally, the synchronous and asynchronous activities were visualized in order to provide teachers and students with an immediate visual aid to facilitate face-to-face interaction in both the local and remote classrooms. When the student's name was called, the demographic information and the asynchronous learning statistics of the student became available for teachers and students to review (see Figs. 3 and 4).

As shown in Fig. 4, the system interface visualized the integrative information to support interactions. Important information for communication in the distance classroom, including the presentation materials, video conference, and asynchronous learning logs, was sorted and presented integratively for all participants in both the local and remote classrooms. The visualization of the integrative information assisted teachers in monitoring the learning process of each student. Students were able to identify and join the ongoing conversation immediately. Additionally, the system could visually compare the learning activities of the student and his group, and of the whole class; as a result, the teacher had a clear and comprehensive view of the students' learning processes (see Fig. 5).

3.4 Instruments

At the end of the semester, all students were invited to evaluate the interaction system to report their levels of satisfaction and the perceived usability and helpfulness of the system. A questionnaire designed by the researchers was distributed to the students and instructors in order to collect their responses to the system. The questionnaire was composed of 20 items to evaluate the perceived helpfulness for learning and interactions at the class, group, and individual levels; the interface and information presentation design of the system; and the ease of adopting such technology in the distance context. Fig. 6 illustrates sample items and the manner of inquiry of the instrument. Additionally, one open-ended question was included to collect the instructors and students' opinions

Fig. 4. Integrative display of synchronous interaction and asynchronous learning.

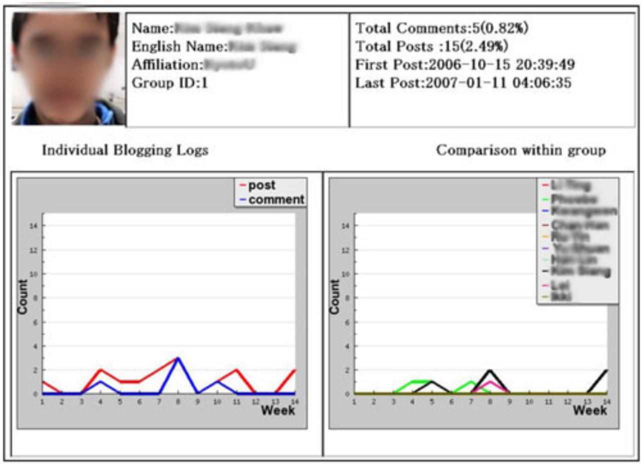

Fig. 5. The details of the asynchronous learning logs.

of and feedback on this system. The internal consistency of the instrument attained a rather reliable level (Cronbach's $\alpha = 0.902$) for measuring the usability of the interaction support system.

4 Results

4.1 Participants

A total of 28 students (12 males and 16 females), most of whom were undergraduate students (79 percent), participated in this study. The students came from various academic majors, including the Liberal Arts, Social Sciences, Science, Engineering, Agriculture, Medicine, and Biology. The heterogeneous grouping resulted in five groups. All students established their individual and group blogs for their learning logs and reflections at the beginning of the semester. Additionally, qualitative data collected by observations and interviews with the five instructors at the two universities were analyzed in order to develop a more comprehensive understanding of the implementation of the system.

4.2 Perceived Learning Helpfulness and Clearness

As shown in Table 1, students rated the interaction support system as a useful tool in terms of the helpfulness (3.99) for their

(A) Evaluation of the Technology			
Applications	Degree of Help	Degree of Clearness	Reasons
(1) For Individual/ Self Learning			
Display individual *learning process*	0 1 2 3 4 5	0 1 2 3 4 5	
(2) For Group Learning			
Display the group learning *outcome/ achievement*	0 1 2 3 4 5	0 1 2 3 4 5	
(3) For Learning in Class Meeting			
Allow me get to know the classmate's *learning status*	0 1 2 3 4 5	0 1 2 3 4 5	

(B) Feeling about the Technology Application		
Applications	Degree of Comfort	Comments
Applying the individual and group learning profiles for students' self-learning	0 1 2 3 4 5	
Applying the individual and group learning profiles for instructors to evaluate students' *learning process*	0 1 2 3 4 5	
Applications	Degree of Fitness	Comments
Applying the individual and group learning profiles for instructors to evaluate students' *learning outcome*	0 1 2 3 4 5	
Applying the individual and group learning profiles for instructors and students' *interaction* in class	0 1 2 3 4 5	

Fig. 6. Sample items of the questionnaire.

TABLE 1
Students and Instructors Perceived Learning Helpfulness and Clearness of the System

	Students		Instructors	
Learning	**Helpfulness**	**Clearness**	**Helpfulness**	**Clearness**
Individual	3.88	3.87	4.5	3.8
Group	3.94	3.79	4.2	3.53
In-class	4.21	4.20	4.27	4.4
Average	3.99	3.92	4.3	3.85

learning and the clearness (3.92) of displaying their learning. More specifically, they viewed this system as helpful for demonstrating their learning profiles in class meetings (4.21), group learning (3.94), and individual learning (3.88). They rated the clearness of the system a little lower than the helpfulness, including learning in class meetings (4.2), individual learning (3.87), and group learning (3.79). On the other hand, the difference between helpfulness (4.3) and clearness (3.85) was obvious from the instructors' viewpoints. The instructors considered the interaction support system to be helpful in assisting them to understand every student's learning status (4.5), followed by understanding each student's learning process (4.27) and group learning process (4.2). With regard to the degree of clearness, instructors considered the information displayed for learning in class meetings to be the clearest (4.4), followed by that for individual learning (3.8) and group learning (3.53).

Students stated that the interaction support system allowed them to know their classmate's names and faces, which significantly increased the feelings of closeness and interactivity in the class meetings, even during video-conferencing. In addition, students felt that displaying individual learning profiles and comparing them to the group members and the whole class helped them to understand their own learning performances and status in the class. Although students suggested that the display should have been clearer, this function was still considered generally helpful. The evaluation results of instructors were consistent with those of the students in that the interaction support system was more helpful and clearer for learning in class meetings than for individual learning and group learning. Although the visualization of interactions stimulated and motivated students to learn and communicate, the presentation was limited to quantitative information and records. The instructors were especially concerned about the lack of indicators for qualitative evaluation, such as the content of a message.

From comments on the open-ended question, it was clear that the students regarded the visual elements of the system as very clear and helpful for them in monitoring their learning progress. The instructors responded that the information was easy to review and that the statistical information was useful in real-time conversations. One student remarked, "Whenever I saw my learning portfolio on the screen, I'd make up the homework which I had not done on time." Students found the display of integrative information useful to "stimulate group members to track their progress" and "motivate members to catch up with the class and get more involved." The graphical presentation was also perceived as more direct and informative for students to get a picture of their individual and group learning progress.

Both the instructors and students of the distance course agreed that the system did support and visualize their interactions in class. Students reported that they had opportunities to review the different methods and strategies of collaboration employed by the different groups, which helped them to reflect on and develop their own group strategies. Student participants also affirmed the association between interaction and learning. They agreed that good interaction in class led to better learning. On the other hand,

TABLE 2
Students' and Instructors' Perceived Comfort with the System

Items	Students	Instructors
Feel ease about the technological incorporation	3.93	4.50
Feel comfortable viewing learning profiles on display	4.11	4.80
Feel comfortable seeing students' self-learning	3.96	4.60
Use the system to evaluate learning process	3.82	4.60
Use the system to evaluate learning outcome	3.82	4.00

the students thought the data should be applied for assessment purposes with caution. For communication and collaboration in groups, both the instructors and students expected the process and more qualitative information to be included for learning assessment. Moreover, the flexibility to include multiple asynchronous tools was also desired.

4.3 Perceived Comfort with the Interaction Support System for Learning

As shown in Table 2, results from respondents' ratings of the ease they felt with using the technological incorporation in the international distance course showed that instructors (4.5) and students (3.93) generally appreciated the application of the interaction support system. Consistently, the instructors had more positive attitudes toward the system than students did. Students felt most comfortable when seeing their individual and group learning profiles on display, which increased instructors' and students' interactions in class (4.11). They also felt comfortable with reviewing their peers' self-learning logs, which they regarded as beneficial for their own learning (3.96). The system was seen to reflect students' learning processes (3.82) and outcomes (3.82). Also, the responses from instructors were in line with those of the students in that they felt rather comfortable with applying the system to facilitate interactions among instructors and students (4.8), students' self-learning (4.6), and evaluation of students' learning processes (4.6) and outcomes (4).

Many students supported the idea of displaying their learning profiles in class. They thought that it was reasonable and that the profiles were useful for self-learning because all the content on the online learning management system, which they wrote themselves, could completely demonstrate their learning processes and outcomes. They also expressed great appreciation that this system could display information in real time, which allowed them to associate their classmates with faces, names, and most importantly, their individual learning profiles. One student described the system as "very convenient. Sometimes someone is speaking but I can't find the speaker. If I can know who is speaking, I can recall what I know of the guy and think more about possible interactions." Instructors also expressed that the interaction support system helped them to recognize and recall students' names and faces, know about their learning progress, and increase the interaction quality among instructors and students. As one instructor noted, "The system is very helpful to instructors. It can help instructors to recall and match the students' names and faces, to understand students learning status/progress, and to provide a better quality of instructor-student interactions in class. In addition, it motivates students to participate and catch up with their learning when they see their classmates' progress."

Additionally, the participants' opinions on camera anxiety were collected to understand whether the integrative presentation of information reduced their motivation to communicate. Student participants reflected that the support this system provided largely reduced their camera anxiety because "the information shown on the screen helped us focus more on the interaction content than before." The results supported a positive connection between synchronous interaction and asynchronous learning, wherein the student participants viewed the displayed information as supporting materials for interaction and were inspired to share and contribute more online.

5 Conclusion

This study proposes an integrative system approach for incorporating technology and designed an interaction system to coordinate instructional, interactive, and technological components in support of international distance education. The systematic perspective to support and motivate synchronous and asynchronous interactions was realized with context-aware applications. As the results showed, the system achieved the goal of increasing the learning involvement, teaching effectiveness, and quality of interactions in the international distance education context by integrating recognition, videoconferencing, and online learning applications. The visualization of blogging activities facilitated the shaping of individual students' identities in the learning community, and both teachers and students could more comprehensively understand the students. Instructors' and students' ratings and reflections on the interaction support system confirmed the system to be an effective solution to overcoming the transactional distance [23] and an aid in stimulating meaningful and smooth interactions in the international distance learning context.

Frankly, both the instructors and the learners recognized the interaction support system to be genuinely helpful in the international distance course. The results suggested that the design and establishment of the system responded to the practical needs of the instructors and students involved in the distance-learning context. Previous difficulties with seeing and knowing one another in telecommunications technology-mediated contexts were solved by incorporating face and voice recognition in this study. The teachers and students all agreed that the system overcame the problem of the lack of interactivity in distance courses. Moreover, the interaction support system integrated and displayed asynchronous learning logs along with the synchronous interactive activities, resulting in a motivating atmosphere for further learning and interaction, one in which instructors and learners felt comfortable taking part.

Although the findings of this study should be generalized with caution, due to the specific case context and small sample size, the noteworthy contribution of this study is that it provides insight for new approaches to integrating multiple technologies and applications with well-designed technological incorporation as an effective instructional strategy [46] to improve the quality of interactions in distance learning. As for the interaction support provided by the current system, the participants' concerns about qualitative information on the interactions could inspire future studies and design modifications, and the visualization of the procedural artifacts in group work could be helpful in motivating task-oriented discussions directly connected to learning.

Lastly, regarding the information design for displaying student learning, instructors and learners in this study suggested a multimodal view for them to select on their own. It is recommended that in the future, more personal devices could be integrated with the interaction support system to provide every participant with alternative views. In addition, future studies that explore more potential uses of the interaction support system will be required to meet the remaining challenges of transactional distance [23], such as the issues of social presence and feelings of isolation.

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