Indicators of Effective Collaboration in Distributed Virtual Teamwork

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Abstract. Graduate-level human-computer-interaction courses were conducted in parallel at two geographically and temporally separated universities. Classes were composed of culturally diverse and globally distributed students. Although basic course content was delivered in asynchronous format, the course capstone was a team project completed during the last four weeks of the course, culminating in synchronous Web-based cross-university presentations in tandem virtual classrooms. During these sessions, each team presented project results in an interactive PowerPoint and question-answer format to a team from the other university. Analysis of (a) within-team interaction during post-presentation debriefing sessions in individual team rooms and (b) team perceptions of cross-team interaction resulted in identification of distinguishing interaction types that are potentially useful as objective indicators for development of dynamic team interaction models.

Introduction

The continuous evolution of online learning technologies requires study of how to meet the practical relevance, domain knowledge, and learning time-place constraints of diverse groups of students. Accumulated knowledge of what has value will provide essential information for design and implementation of more effective learning tools and support systems. While analysis of asynchronous interaction can be somewhat helpful in determining how best to design a given course, synchronous interaction episodes are more intense and more like face-to-face interaction so that they are more readily productive of information about how students interact to build shared conceptual understanding of important learning domain concepts. This study analyzes a speech corpora comprised of nine team course summary discussions in an effort to isolate (a) common types of within team interaction as an indicator of how individual teams managed interaction and knowledge construction and (b) individual and team preferences for collaborative interaction type. The first analysis provides helpful insights into how actual use information was acquired and how this information might provide specification of models of group interaction. The second analysis examines individual and team preferences for types of collaborative interaction, which may be useful in considering objective indicators of collaborative task performance preferences. These two kinds of information converge to provide insight into whether explicit group models or dynamic combinations of individual models might best expedite development of better collaborative learning technologies.

Course Description

Entirely asynchronous or synchronous online courses provide unique value. Elements of each can be combined to leverage the advantages and disadvantages (Vick, 2002) of both. The course discussed here was such a hybrid. Exploratory (Wiedenbeck & Zila, 1997) and experiential (Dehler & Porras-Hernandez, 1998) synchronous elements were added to a graduate computer science course in Human Computer Interaction (HCI) previously offered in face-to-face (FtF) mode or as an asynchronous online course. Students were prepared for the hybrid environment by supplementing content with readings and discussion on teamwork and computer supported collaborative work (CSCW). The enhanced pedagogical design provided students with the opportunity to experience the benefits of "collaborative persistence" by working with others during the project-based (Barron, Martin, Roberts, Osipovich, & Ross, 2002) synchronous phase of the course.

Students from both classes migrated to a common Blackboard (Bb) site for the team project phases. This move to a new virtual setting for the team project had symbolic and practical advantages: (1) Working at a new site created a clear separation in students' minds between the asynchronous and synchronous course phases and was symbolic of engagement with new others in a more professional teamwork forum. (2) Location at a single site enabled free movement between private team rooms and virtual classrooms by individual and tandem teams at the same time. (3) Posting assignments and updates was simplified, reducing potential confusion. (4) All synchronous online team chat and discussion list postings were archived in one place for easy reference during and after the project. Students had little or no difficulty adjusting to use of a different support system. All students had to remain cognizant of their "home base" learning support systems.

The main goals of this graduate Computer Science elective were to enable students to develop an understanding of HCI design and usability principles and to provide the opportunity to apply these principles through performance of basic HCI evaluation methods. The course was presented simultaneously at the University of Hawaii Manoa (UHM) using WebCT (**http://www.webct.com**) courseware and at California State University Fresno (CSUF) where Blackboard serves as support. (**http://www.blackboard.com**). Basic content and format at both universities was the same. Topical weekly commentaries prepared by one instructor were posted on the respective course Web sites. The virtual text-based lectures were accompanied by related online and text readings, a topical discussion list, and individual student assignments. The courses were conducted separately, asynchronously, and in parallel until introduction of synchronous teamwork during the last four weeks of the courses.

In addition to institutional diversity, a considerable degree of cultural diversity was present. The classes included students from the Indian subcontinent, Southeast Asia, South America, the continental United States, Hawaii, the People's Republic of China, Taiwan, and Northern Europe. This diverse group of students contributed a rich variety of perspectives. The boundaries of time and space also complicated the synchronous portion of the course since many students were permanently geographically distant while others were traveling.

Final Project

The final assignment for the course involved performance of a cognitive walkthrough (CW) (Blackmon, Polson, Kitajima, & Lewis, 2002; Lewis, & Wharton, 1997; Virzi, 1997) as the capstone project, which consisted of four phases: (1) individual student CWs, (2) same-university teams reviewed their individual CWs and prepared PowerPoint presentations, (3) complementary (tandem) teams (one team from each university) exchanged presentation of their CW results in synchronous online group sessions, and (4) all teams prepared project evaluations.

Phase 1: Individual Cognitive Walkthrough

Students individually reviewed the user interface for the David Rumsey Historical Map Collection (**http://www.davidrumsey.com**) using the cognitive walkthrough method. This Web site is enabled by Luna Imaging, Inc.'s in*sight*™ browser for novice users as well as by their in*sight*™ Java client and Telemorphic, Inc.'s GIS browser for more advanced users. A review of students' work after the individually-performed CW indicated that many students had confused cognitive walkthrough with the summative usability study they had done for an earlier assignment. The distinction between the two usability inspection methods can be difficult to comprehend and depends to some extent on a student's familiarity with human factors analysis, educational theory, and principles of cognitive psychology. In order to fit the CW into the timeframe of the course, we requested students to do the CW on an already deployed Web site. To students, the CW appeared similar to the usability study they had done earlier since the CW evaluation assignment was summative, too, rather than formative as is usual for a CW. Discussion questions and exemplary individual student CWs were posted on the common Bb Web site to assist student learning and to stimulate discussion and reflection about the intent and value of CW as an assessment method. In addition to course material (Nielsen, 1993), students were referred to Web resources where they could learn more about performing CWs:

http://www.cs.umd.edu/~zzj/CognWalk.htm
http://www.acm.org/sigchi/chi95/Electronic/documnts/tutors/jr_bdy.htm
http://www.cc.gatech.edu/computing/classes/cs6751_96_winter/handouts/cognitive-walkthrough.html

Phase 2: Team Review

Students were randomly assigned to four-member zero-history teams. Chat transcripts indicated that students experienced varying degrees of communication apprehension (Daly, McCroskey, Ayres, Hopf, & Ayres, (Eds.) 1997; Wright, 2000) about meeting new teams in a virtual environment. Private meeting rooms were set up for the five UHM and four CSUF teams at the common Bb site. Teams met in private team rooms to prepare for presentation to their other-university counterpart teams. PowerPoint slides were created to demonstrate interface area assessed, conclusions reached, and decision rationale. The autonomous teams met online as they deemed necessary to combine individual CWs or perform new team-generated analyses. Fifty-five meetings were held with number of meetings per team ranging from one to fifteen. Wide disparity in pre-presentation synchronous online effort expended by each team is seen in Figure 1.

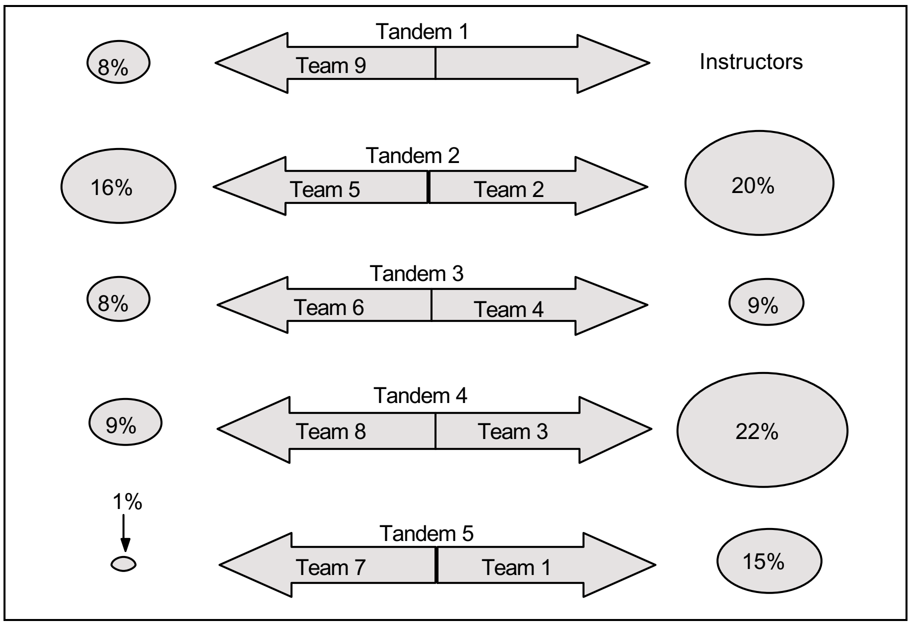


Figure 1: Pre-presentation team chat lines as a percent of all chat lines ranged from 1% to 22% of the overall online total of 17,540 on-task lines for all teams. Because Team 9 presented to the instructors, it is shown for illustrative purposes only (Teams 1 – 8 = 100%)

Phase 3: Final Presentations

Four teams from CSUF were randomly matched with four teams from UHM to form tandem presentation pairs. The unmatched fifth UHM team presented to the "Instructors' Team." In two cases, two tandems presented at the same time. Each instructor was able to attend a large part of each of these four overlapping team presentations. Up to eleven participants were active in chat at the same time in a Bb Virtual Classroom. Presentations were sequential and interactive since presentation protocol stipulated that anyone could ask questions at any time. Despite potential "text-chat anarchy," presentations went smoothly. Teams either allocated time for questions after each slide or accepted ad hoc inquiries.

Tandem meeting rooms at the common Bb site provided access for the eight members of each tandem and the instructors to a common Bb Virtual Classroom (shown in Figure 2) for the reciprocal presentations. Multiple deployment of Bb meeting rooms afforded separate virtual spaces for simultaneous tandem presentations as well as facilitating instructor movement between rooms. Although tandem rooms were available for pre-presentation inter-university meetings, teams did not make use of them for development of common ground prior to the presentations.

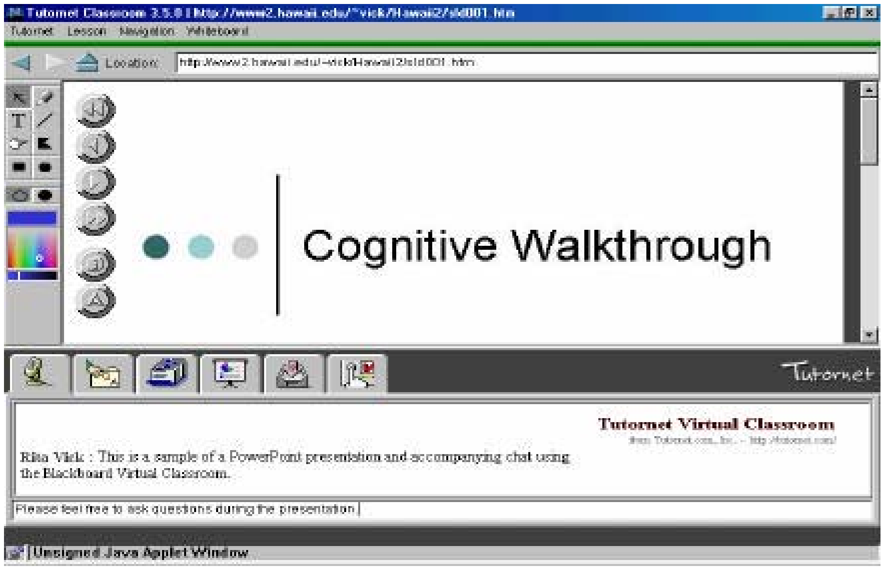


Figure 2: Blackboard Virtual Classroom: URL pointing to the PowerPoint presentation (top), initial slide (center), chat transcript area (below slide image), and chat text entry box (bottom)

Participants were globally distributed during the presentations making it difficult to schedule a meeting time. Based on Hawaii Standard Time (HST), a student in the People's Republic of China was 18 hours ahead, a student in Boston was six hours ahead, a student in Chicago was five hours ahead, and all students in California were three hours ahead of HST. The instructors were in California and Hawaii. Despite this, only one member of the nine teams was unable to attend the team presentation.

Phase 4: Debriefing

After the presentation sessions, each team prepared a final summary report. Teams were asked to submit short individual team member reports or to conduct a debriefing session in their team chat room. All but one of the nine teams chose to conduct a chat session. Four teams met immediately after the presentation for this wrap-up session. Four teams met the next day. The members of one team submitted brief individual written summaries six to nine days after the presentation. Students were encouraged to discuss anything relevant to the course, including their perceptions of the team experience, the project, presentation to the other-university group, and the synchronous format.

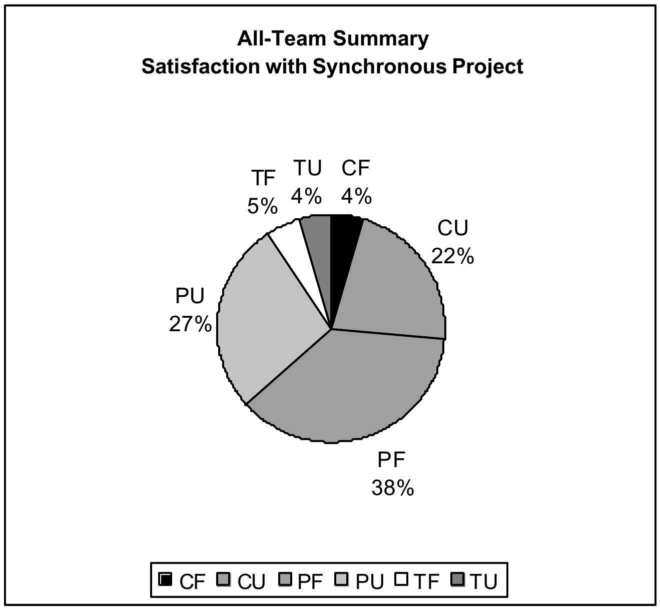
Results

The team debriefing conversations provide a rich source of interaction information. The data informing the following discussion are the post-presentation chat transcripts analyzed for interaction type as well as satisfaction with task, synchronous teamwork, and interaction with counterpart team. Analysis is limited to frequency, source, and content analysis of transcripts in search of potential indicators of unique versus stereotypical interaction at the individual and team levels.

Satisfaction

Review of the transcripts revealed more positive than negative comments indicating satisfaction with the overall Final Project *process* and *task*. There was, however, prevalence of negative statements made by most teams concerning interaction with members of the other-university team during the presentations. Figure

3 shows overall positive and negative statements for all teams as percentages of all post- presentation statements. This was somewhat unexpected since there was little or no indication of friction between teams during the presentations. One tandem had experienced problems in establishing a mutually acceptable time for their presentation. This may have predisposed one or both of those teams to be more critical than they might otherwise have been. These two teams were among the six teams with net unfavorable comment totals regarding their counterpart teams. In the case of the other four teams with overall negative responses to the counterpart teamwork experience, reasons for negativity appeared to be related to a combination of social, cultural, and presentation performance quality factors. Interestingly, one of these last four negative-balance teams received more favorable than unfavorable comments from their counterpart team.



CF = Counterpart Team Favorable — **CU** = Counterpart Team Unfavorable
PF = Process Favorable — **PU** = Process Unfavorable
TF = Task Favorable — **TU** = Task Unfavorable

Figure 3: Combined favorable and unfavorable opinions of all teams shown as percentages of the aggregate for all teams

Interaction

The teamwork portions of the CW project consisted of team interaction and tandem interaction. Individual team interaction took place before and after the tandem presentations. Pre-presentation team collaborations, tandem presentations, and post-presentation evaluative meetings produced forty-six, five, and eight transcripts, respectively. (One team chose to submit individual post-presentation evaluations.) The focus here is on the individual team evaluative wrap-up discussions in terms of (1) type and quality of interaction and (2) satisfaction with the team, task, and process elements of synchronous interaction during the tandem presentations. Analysis of text and speech corpora can be used to analyze collaborative learning patterns. These patterns can then be used to construct models of learners' cognitive, kinesthetic, and interaction behaviors for subsequent development of adaptive learning technologies that may or may not be driven by intelligent agents. Analyses of this type can also provide input to language and dialogue modeling to determine discourse structure and analysis of meaning (Jurafsky, Bates, Coccaro, Martin, Meteer, Ries, Shriberg, Stolcke, Taylor, & Van Ess-Dykema, 1997; Deerwester, Dumais, Furnas, Landauer, & Harshman, 1990). In order to understand the debriefing sessions, it is necessary to know something about interaction during the presentations, themselves. Table 1 lists the kinds of synchronous interactivity that occurred during the tandem presentations. Listed definitions are exclusive of extraneous activity such as browsing to organize slides or exit to private team rooms for virtual caucuses and subsequent reentry to the tandem presentation room.

INTERACTIVITY (Source: Tandem Presentation Chats)	
1-Within Team:	conversation directed to a member of one's own university team
2-Between Teams:	conversation directed to a member of the other university's team
3-Across Teams:	conversation directed to anyone/everyone present in the virtual classroom
4-Browsing:	calling up slides from Bb (or other) server
5-Entry/Exit:	entering or leaving the virtual classroom

Table 1. Types of interactivity within, between, and across teams during team presentations

Discussion

Figure 4 shows the aggregate breakout for categories of satisfaction discussed by all of the teams from one of the two universities during the post-presentation debriefing. The breakout is by codes referencing satisfaction with task, process, and counterpart team. However, this breakout is used here as an example of only one of many dissections of the conversation that could be made.

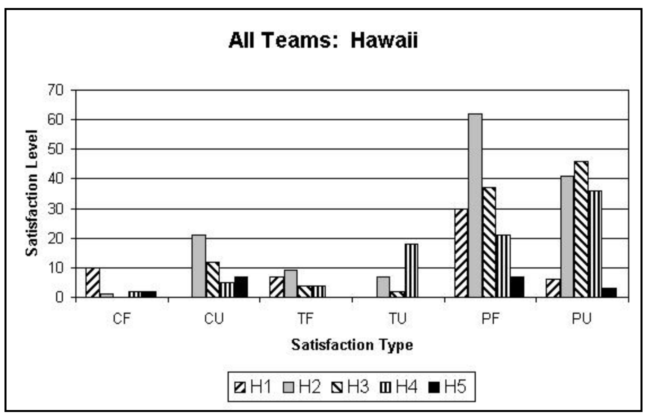


Figure 4: For illustrative purposes, the "Satisfaction" levels and types for each of five teams are shown as collected through analysis of the chat transcripts of all teams for one of the two universities involved in the cross-university presentations

Figure 5 shows a breakout for categories of satisfaction discussed by one team during the post-presentation debriefing. This kind of interaction analysis might be used for development of explicit group models. Figure 6 is a portion of the analysis by satisfaction type for the team shown in Figure 5. This part of the analysis shows that the virtual debriefing meeting lasted approximately forty minutes and generated 317 lines of text. The part of the discussion that generated exchange of discourse related to satisfaction with task, process, and counterpart team was 44% of the overall conversation. The remaining 56% of the lines generated was accounted for by movement in and out of the virtual meeting room, browsing slide content, or checking Bb file and discussion areas. The patterns indicate the type of interaction being engaged in for the chat segment as well as the team members involved in the information exchange.

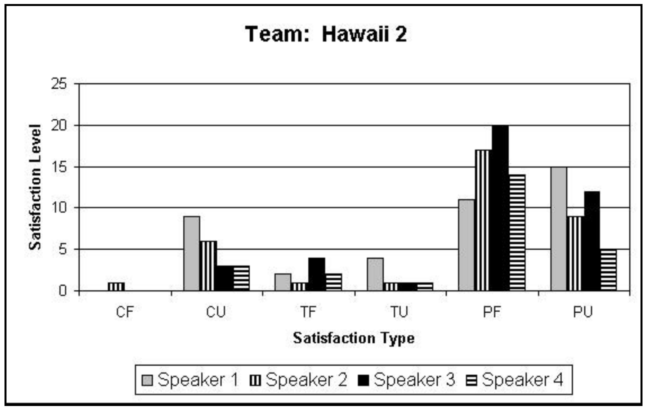


Figure 5: Illustration of the "Satisfaction" levels and types for one team debriefing session

For example, the second pattern segment is a Process Favorable (PF) exchange sequence consisting of nine statements during which all members of the team contributed at least one comment. The percent of each team member's contribution to the overall conversation by number of statements related to content (Content) versus other activities (NA) is indicative of the evenness of participation by team members. This analysis could be refined further to show type of content contribution.

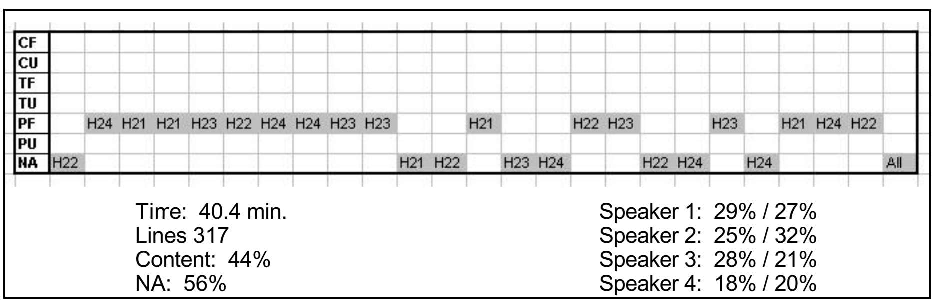


Figure 6: Illustration showing the "threading" pattern and participation in interactivity by individual team members for one part of one team's debriefing conversation

There were significant differences among the nine teams with respect to type and quantity of contribution. It is clear from some transcripts that teams had developed quite different interpretive frames, or schemas, reflected in the tone of the presentation. Because some teams had failed to "establish and maintain common ground" (Mäkitalo, Häkkinen, Salo, & Järvelä, 2002), one team might, for example, persist in attempting to lighten the presentation, much to the annoyance of a more formal and businesslike counterpart team. One team might have developed strong cohesiveness through regular, focused, online work sessions while another team had fewer and less focused online sessions developing little apparent cohesion. Lack of expected kinds of feedback during the presentation led to a "large amount of subjective interpretation of the shared artifacts and of the other participants' thoughts about the same issues" (Baggetun, & Mørch, 2002). The tandem rooms were available during the pre-presentation phase of the project. Tandem teams could have met, become grounded in one another's presentation styles, and established common presentation protocols.

Summary

As illustrated above, many characteristics of individuals as well as teams can be isolated so as to be reliable and objective indicators of different elements of the collaboration process. Because of the emergent nature of group interaction patterns, evolution of individual belief structures during the work process, and the emergence of new knowledge that is used in new ways, it is difficult to conceive of anything other than a dynamic combination of action-response patterns as the basis for models of group activity. The method of analysis of interaction suggested here is potentially useful for development of collaborative task models as well as for models of group knowledge management.

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