Sharing Visual Context to Facilitate Late Overhearer's Understanding of the Handheld-Based Learning Activity

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Abstract: Peripheral participation is fundamental to collaborative learning. In the classroom, we see two situations in which peripheral participation is essential: *formative assessment*, during which a teacher attempts to assess the utility of an ongoing activity and intervenes if necessary; and *peer-monitoring*, during which a student attempts to learn what other students are doing. When augmenting the classroom with handheld, wireless computing devices, handling peripheral participation becomes more difficult. The proposed new handheld network service, *Look*, allows a late overhearer, who has not witnessed the creation of common ground, to monitor the interaction between group members already engaged in a collaborative situated learning without interrupting. Laboratory experiences with our prototypes indicate that *Look* balances lightweight implementation, ease of use, and utility in a way that could enhance classroom communication and learning.

Introduction

In discourse, people frequently switch their roles between *central participation* (such as speakers or addressees) and *peripheral participation* (such as overhearers or bystanders). Many computer-supported collaborative learning (CSCL) or computer-supported cooperative work (CSCW) tools focus on supporting central participants in a communication; however, none that we know of focuses on peripheral participants—that is, those who are attending to the conversation overtly or covertly but are not current addressees or responders. Considerable evidence exists that such participants have different access to information and different cognitive burdens than do central participants. However, very little is known about how to support their needs, especially in light-weight interactions. In classroom group activities, active changes of social roles occur often. When we introduce handheld technology, we change the affordances available to peripheral participants. In the context of task-oriented discourse processes with handheld computers, in this paper we focus on one type of peripheral participant: an *overhearer*. We (1) analyze the challenges faced by overhearers, (2) suggest a possible solution to overcome the challenges of overhearers within the constraints of our vision of classroom use, and (3) report experimental results showing the proof-of-concept of our solution in an abstracted form.

Restrictions Faced by Overhearers

The problem of *overhearer sufficiency* occurs when two people engage in a primary task involving face-to-face focused interaction using handhelds as well as speech, while a third person, the overhearer, must monitor or join the interaction. In the classroom, this problem takes two forms: *formative assessment*, during which a teacher attempts to determine whether the activity happens in an appropriate and sufficient manner and intervenes if it does not, and *peer-monitoring*, wherein a peer attempts to learn what is happening and join the activity. At its most general, the problem can arise whenever one or more people focus on information that cannot be seen by a latecomer, making it difficult for the latter participant to gauge interruption and thus raising the effort involved in attaining sufficient common ground for informed participation.

According to Schober and Clark (1989), in actively collaborating to reach common ground discourse participants possess an advantage over an overhearer because they have understood each other's intentions. Simply put, discourse participants engage in a process of gathering the moment-by-moment evidence necessary to ensure that what is said is understood. For example, periodically a speaker might check an addressee's understanding before proceeding in the conversation and an addressee might also respond to a speaker to clarify points of confusion. This paradigm presents the collaborative view of language usage.

In such a collaborative situation, overhearers face several disadvantages in understanding what is said. First, an overhearer has limited resources in grounding the mutual beliefs, knowledge and assumptions required for current purpose of understanding conversation. (Grounding refers to the interactive exchange of evidence by discourse participants regarding what is understood.) Overhearers cannot join the process of coordinating between a speaker and an addressee. Instead, they receive only what is given by central participants (i.e., speaker and addressee). Second, overhearers cannot control the pace of the conversation, and once they lose track of the content, their misunderstandings can accumulate easily. Overhearers must contend with each speaker's next utterance while trying to complete understanding of the last one. They do not have an opportunity to keep the speaker informed of the state of their confusion and clarify misunderstandings. Third, although an addressee can determine what a speaker means from conclusive evidence of their common ground, an overhearer, on the other hand, can only conjecture about what the speaker means using inconclusive evidence. This problem intensifies if overhearers were not present to witness the buildup of common ground between conversational participants. Without knowing what constitutes the speaker's and addressee's common ground, the overhearer finds it difficult to determine exactly what the speaker means. In most, if not all cases, the overhearer's only recourse is to conjecture based on his own assumption of common ground between a speaker and an addressee.

Handheld Devices

Since we are supporting both monitoring and the potential for joining the conversation adeptly, we are concerned with device mobility. Handhelds have a relatively restricted bandwidth for wireless communication. Furthermore, we need utmost simplicity in usage. Therefore, we must ask about the utility of *minimal* representations that enable peripheral participation. Full monitoring is not an option.

To meet these concerns, we designed a new handheld network service called *Look*, which provides overhears with the ability to engage in real-time capture of activities and focal artifacts from other handheld screens by infrared (IR) beaming or radio frequency (RF) communication. *Look* allows peripheral participants to get a snap shot of another person's screen. This synchronized visual co-presence can establish that the items or concepts indexed are within the joint range of attention and enable participants to focus on the topic rather than on the technology.

Experiment

We studied the utility of *Look* in a laboratory setting that abstracted and intensified the need for shared visual understanding compared its natural occurrence in the classroom. The experiment contrasted two different settings. In one, the overhearers had *Look* implemented with Bluetooth technology. In the other, they did not. The main participants engaged in a game that involved rearranging Korean characters (KCs) on the screen to put them in a specified order. Our hypothesis was that, compared to *No-Look*, *Look* improves how an overhearer understands a conversation.

Forty-four groups of three were recruited from the psychology subject pool at Virginia Tech and randomly assigned to condition. Participants in the main task were trained in the names of KCs and asked to use them in accomplishing the task. The principle test of the benefits provided by *Look* was based on accuracy—in this case, the percentage of KCs placed correctly. According to our hypothesis, the late overhearers whose handhelds were equipped with the *Look* functionality should better understand the conversation and be better able to rearrange the figures correctly. This was precisely what occurred. Through all three trials, late overhearers in the group that had access to *Look* experienced significantly fewer errors than did those who were not supported with *Look*. When the late overhearer first entered the discourse, in trial 3, those who had access to *Look* were able to place 90% (SD: 17.6%) correctly, compared 69% (SD: 24.2) of those without *Look* (F (1, 41) = 11.15, p < .002). As the task was repeated from trials 3 to 5, correct placement increased in both the groups with *Look* and without *Look*. However, statistically significant differences remained through trial 5 between groups with and without *Look* (F (1, 43) = 9.97, p

< .003 on trial 4; F (1, 40) = 9.87, $p < .004$ on trial 5). These differences suggest that the *Look* handheld network service, which provides a visual context for focal artifacts, greatly influences an overhearer's understanding of the conversation. A second test was used to gauge, in a limited way, learning. After each trial, participants were asked to choose a name for each KC. Over all three trials, the percentage of correct naming of the KCs was higher for the groups who had access to *Look*, though the effect was in some cases small. Specifically, on trial 4, an analysis of variance yielded a significant advantage, with F (1, 44) = 4.15, $p < .05$. The result showed also marginal improvements on trial 3 and 5 (F (1, 44) = 3.22, $p < .08$ on trial 3; F (1, 43) = 2.44, $p < .125$ on trial 5).

Discussion

Active participation in conversation is not the only means by which learning can occur. Because it is fundamentally a social process that dwells in contextualized settings, learning also takes place through the observation of others (Stenning *et al.*, 1999). Technologically, such an understanding demands that we shift the way we approach collaborative learning. New technology paradigms broaden the scope and style of interaction beyond the desktop into the real world, where users encounter increasingly rich contexts. For example, the mobile nature of handheld devices like a $100 Laptop, Tablet PC, Pocket PC, and Smartphone offers students new opportunities for increasing interaction and facilitating collaborative learning. Devising a solution that within any particular situation satisfies both varying human needs and capabilities and the affordances of mobile computing presents unique design challenges. In this project, we worked through the particular set of design problems, how to use handhelds to promote the rapid acquisition of common ground and shared meaning for peripheral participants.

To support overhearers, we implemented special and even idiosyncratic handheld network features and tested under experimental settings that closely approximate the range of situations that we find in classroom learning aided by ubiquitous and pervasive computing devices. The proposed new handheld network service, *Look*, allows a minimal but moderately up-to-date view of the task state. It maintains awareness, and enables improved understanding based on that awareness. User experiences with our prototype provide preliminary indications that *Look* could enhance classroom communication and learning. Two outcome measures were used to assess the benefits of a peripheral participant having the prototype versus not having it, placement correctness and naming KCs. Based upon our initial findings, we expect that our studies will contribute in important ways to the ongoing discussion among educational researchers and computer scientists in designing mobile computing systems that will enhance future ubiquitous classroom.

The project reported in this paper is part of our continuing study investigating the influence of shared visual context on the learning for many different types of peripheral participants, including side-assistants and side-participants (Kim & Tatar, 2005; Kim *et al.*, 2006). In this study, we showed a clear advantage to overhearers from access to the *Look* feature. In real classroom settings, we argue that the need for *Look* may not arise often, but is important when it does. Therefore, to avoid misunderstanding and to allow flexible entry into conversations, it is worth the difficulty and expenses of implementing what may appear to be "extra" functionality. Further, we have shown that such functionality can be useful without increasing the computational cost of continuous monitoring.

References

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