**Spontaneous Collaboration:
Perspectives from Computer Supported Learning, Play, and Work**

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Abstract

The purpose of this project is to investigate spontaneous (informal) collaboration and learning emerging from three contexts: in a classroom (Computer Supported Collaborative Learning), in game playing setting (Computer Supported Collaborative Play) and in a workplace (Computer Supported Collaborative Work). The converged results from three independent studies indicate the spontaneous collaboration happens, often despite the fact that the technology and/or the rules are not designed (intended) for collaboration. The spontaneous collaboration is both enabled and constrained by the participants' task goals and social goals. In the process of collaboration, participants appropriate the rules and artifacts to serve their purpose. Other issues such as the nature of learning, blurred distinction between learning, play and work, and the evolution of a community of practice are discussed. The implications for teachers, program designers and managers are presented.

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Purpose and Perspectives

The purpose of this work is to investigate spontaneous (informal) collaboration and learning emerging from three contexts that are not intended for "legitimate" learning: (1) a group of first graders playing games together at a classroom computer despite the teacher's rule to limit participants to only two; (2) college students helping each other although they were playing competitive console video games; and (3) workers in several workplaces helping each other to use computer applications to achieve their work goals. We are interested in the following questions: Why does this kind of spontaneous learning happen even in rather surprising contexts? How does this learning and collaboration contribute to the work and tasks on hand? How do the participants appropriate the mediational means including computers to serve their goals? What kind of functions do computers perform in these contexts? How can computer designers, teachers or managers facilitate this kind of spontaneous collaborative learning?

Many researchers have taken notice of and speculated on the potential value of different forms of spontaneous collaboration, for example, children milling around computers in classrooms and contributing suggestions or comments to the ongoing activities (e.g., Bruce, Michaels & Watson-Gegeo, 1985; Freeman & Somerindyke, 2001). While playing games, players often voluntarily share tricks and even build database to formally exchange tips on the Internet (Gee, 2003). In the workplace, computer programmers offering debugging tips to each other around the water cooler (Weinberg, 1971). One aspect of spontaneous collaborative learning is that the participants were involved in a different, larger task that gets 'interrupted' by a learning need that is addressed collaboratively. For example, in the workplace, a person may be trying to produce a report, but discover that they cannot format the report the way they want. After attempting and failing to solve the problem on their own, they may ask a nearby colleague for help. Help-giving in the workplace has been the subject of considerable study, and is an important part of organizational learning (Twidale, 1999). Technical help-giving relating to the use of computer applications is a particular case of the broader phenomenon.

Although the fact of spontaneous peer help is well recognized, few researchers have investigated how it operates. Although many studies in computer supported collaborative learning (CSCL) and work (CSCW) focus on designing systems to facilitate and support formal collaborative learning and work (e.g., Olson & Olson 1997), few researchers have paid much attention to spontaneous collaboration naturally occurring in technology rich environments. Consequently, we know little about spontaneous computer oriented collaboration in daily situations in workplaces, schools and play. Thus, this study is designed to explore this phenomenon as well as to address some holes in the fabric of existing research.

This project is strongly influenced by situated learning theory (Lave & Wenger, 1991) and its view that participation in social practice is the fundamental form of learning, and that sustained learning embodies a change of the community of practice as well as of each participant. Adapting this theory, many researchers have explored how newer members evolved their participation in a form of apprenticeship. For example, Rogoff (1995) studied girl scout selling cookies and how experienced members scaffolded and helped young ones improve their selling and book keeping skills. However we expand their view of learning in practice that takes the form of apprenticeship and exchanges between old-timers and newcomers. We focus on contexts where expertise is more evenly distributed among peers, so that the roles of master and apprentice are fluid, changing over time, or even inappropriate with both or all participants simultaneously learning and teaching. This perspective fits very well with Fischer's (2000) exploration of the symmetry of ignorance in high functionality applications, where each user may know a different subset of the available features and uses of the application.

We also draw perspectives from sociocultural theories, especially its emphasis on mediational means-- including social and discursive practices as well as materials and tools-- as key to understanding the relationship between human leaning and development and their social cultural settings (Cole & Wertsch, 1996; Wertsch, Tulviste & Hagstrom, 1993). Sociocultural theories held that cultural artifact mediation provides the means to identifying "how human intelligence and mental processes are situated in cultural, historical, and institutional contexts" (Wertsch et al., 1993, p. 352). This is because of the duality of artifacts (Bødker, 1997) -- artifacts are objects in the world that we reflect on, and they also mediate our interaction with the world of objects and other people, as stated by Leont'ev (1981):

> The tool mediates activity and thus connects humans not only with the world of objects but also with other people. Because of this, humans' activity *assimilates the experience of humankind.* This means that humans' mental processes (their "higher psychological functions") acquire a structure necessarily tied to the sociohistorically formed means and methods transmitted to them by others in the process of cooperative labor and social interaction. (p. 56)

In recent years, a growing body of research places artifacts and their affordances at the heart of analytic agenda for both sociology and cognitive science (Heath & Hindmarsh, 2000). Some well-known sociocultural studies which articulate and analyze the use of specific cultural artifacts as tools for thinking and learning include a wide range of contexts, for example, oceanic navigation (Hutchins, 1995), ironwork in a blacksmith's shop (Keller & Keller, 1996), dairy work (Lave, 1988), and weaving (Rogoff, 1995). Along this line of study, we are interested in the semiotic mediation of cultural artifacts and how participants socially negotiate and appropriate those artifacts to serve activity-centered goals. The computer, especially what appears on the computer screen, is central to the contexts we studied, but in addition, we note how even mundane objects like desks, chairs and paper may also shed light on the nature of knowing and doing in these communities (Dewey, 1920).

Methods, Data Sources and Data Analysis in Three Contexts

The three studies outlined below were developed independently using different methodologies and to some extent informed by different intellectual traditions (child development, educational theory, psychology and computer science). It was only afterwards that the authors began to compare notes, discovered surprising similarities and re-examined their data in the light of their growing understanding. We need to note the lack of consistency in the approaches between the three studies is caused by their independent nature. Although this makes for a weakness in systematic comparisons, we believe it serves to reinforce the triangulation of the findings we outline in this paper.

1) CSCL: Young children's group work on a classroom computer (Wang, 2003)

This study was conducted in a first-grade classroom at a public school located in a Midwestern town. The school population comes primarily from working- and middle-class families; 37% are from low-income families and are eligible for free lunch. The average first grade class size is 18 in both the school and the school district. In the classroom where the study was conducted, there were ten boys and six girls between the ages of 6 and 7. Among the sixteen students, two were African-American, two were Asian-American, and the rest were Caucasian.

There were two Macintosh computers in the classroom positioned next to each other against the back wall. Two chairs were placed in front of each computer. Computer 1 had an Internet connection and was connected to a printer. Computer 1 was also a newer iMac loaded with more recently released games such as *Nanosaur*™ and *Putt-Putt Saves the Zoo*™ The students were observed using Computer 1 most of the time; occasionally Computer 2 was used by those students who were waiting to use Computer 1. Consequently, the majority of the data collected and analyzed for this study focused on student interactions around Computer 1. In this classroom, the students could use the classroom computers for work or games only during "choice time," between 2:00 – 3:00 p.m. from Monday to Thursday. Using a computer as a choice time activity was among the few choices that limited participants to a maximum of two at a time.

The year-long fieldwork went through three stages: gaining entry; establishing rapport and collecting data. The researcher visited the classroom an average of 2-3 times a week. Most of the data was collected during children's choice time when they could use computers. Videos were the primary data source for this study, as suggested by the interaction analysis approach (Jordan & Henderson, 1995), because they are capable of capturing the richness and fluidity of social interaction as it naturally occurs. Videos were shot of children in front of the two computers and were used for microanalysis of their interaction. A total of 26 choice-time sessions of video were collected, each session lasting about 25-35 minutes. Other data sources, including 45 sessions of field notes, artifacts, and interviews. Field notes complemented the video data and helped to capture and situate the video data in the whole class culture. Interviews with all the students were used to gather the participants' perceptions of their peers, the computers, and their interactions at the computer. Teacher interviews revealed the insider's point of view of the class, peer culture, and the computer curriculum. Finally, the artifacts included the students' computer work and log, their waiting list for the computer, and the choice time log.

During the first stage of data analysis, I mostly followed the interaction analysis approach to deal with the video data. I created content logs after each session of video taping, which were indexed by time and consisted of a general heading followed by a very rough summary listing of events and involved participants as they occurred on the tape. These content listings were useful for providing a quick data overview and locating specific events and issues (Jordan & Henderson, 1995). I then adopted the descriptive coding categories suggested by the interaction analysis approach to code the all the videos, as follows: (1) the structure of the event; (2) the temporal organization of the event; (3) the spatial organization of the activity; (4) participation structures; (5) problems and problems solving; and (6) artifacts and documents.

In the second round of data analysis, I mainly dealt with transcribed video sessions. I applied Grounded Theory to develop an interpretation and theory of children's socially constructed computer experience in the classroom. The testing of the theory and interpretations was guided by a theoretical sampling technique. In addition to vigorously applying interactional analysis and grounded theory approach, I used other means to warrant the trustworthiness of our analysis, most of which involved considering multiple participant perspectives. Some video clips were shown to the students and teachers to ask for their interpretations and share mine. Many interview questions were also designed to clarify and question the teacher and the students' views as gathered from observations or early communications. Peer debriefing is another powerful means I applied to achieve trustworthiness. I showed videos to fellow researchers and other classroom teachers and exchanged and discussed our interpretations. My interpretations were solidified or challenged and adjusted through those debriefing sessions.

2) Computer Supported Collaborative Play (CSCP): College students play on console video games (Hinn, in progress)

The purpose of this study was to investigate "help giving" and "help seeking" activities that occur during competitive versus cooperative video game play. Twenty-four usability sessions were conducted with groups of undergraduate friends (age range of the participants was 18 - 24) at a large Midwestern university. The sessions were divided into eight male and eight female dyad sessions and four male and four female triad sessions and in each session participant groups played two different console games – Tennis 2K2 for the Sega Dreamcast and Halo for the Microsoft Xbox. Half of the dyads and all of the triads played both of these games in competitive (e.g., against one another) game play mode and the remaining half of the dyads played both of these games in cooperative (e.g., in order to win the game participants were required to work together) game play mode.

In a typical usability session, a single participant is asked to verbalize their plans, reactions and concerns as they work through the task(s) that they have been asked to complete. This is commonly referred to as the "think aloud" protocol where, literally, the participant is asked to repeat their thoughts out loud about the task at hand and the program being tested (e.g., Nielsen, 1993; Rosson & Carroll, 2002). Here is an example of what a user might say while "thinking aloud" is:

> So I was given this list of things that I'm supposed to be doing…first…need to start a new game in "legendary mode." So…ok…I see here… "new game." Ok but I don't see anything about legendary. Hmm. Wait…I wonder if it's like that game that I have at home where I have to go into the "game settings" to do that…

The think aloud protocol is used in order to gain a better understanding of how users are viewing the software. However, this popular usability study technique also carries some distinct disadvantages in that having a user "think aloud" is not natural behavior for many computer users and may result in slowing some users down or causing them to focus much more on a task than they would in daily life (e.g., Berry & Broadbent, 1990; Wright & Converse, 1992). Additionally, a researcher may fall into a situation where they inadvertently bias the results of the study by interacting too much with the participant since the participant has no one else to turn to for questions about the system being tested (Kahler, 2000).

One method that has arisen as a way of addressing some of the disadvantages of the think aloud protocol is the constructive interaction (sometimes referred to as co-discovery learning) method (Miyake, 1982; Miyake 1986). This usually entails having two users working together to complete a list of tasks provided to them and discovering together how to use the software without prior training. They also talk to each other versus interacting with the usability engineer running the test. The way that many usability researchers (e.g., O'Malley, Draper, & Riley, 1985; Kennedy, Niergarth, & Cuddy, 1985; Hackman & Biers, 1992; Westerink, Rankin, Majoor, & Moore, 1994; Wildman, 1995; Kahler, 2000) have reported using this method in the literature has been as a way to gather single user data in a more "natural" way. For example, the researchers applied what they learned from the pairs to improving the single user experience, as many of the products that they were testing were classically considered single user products.

For the present study on gaming, however, the focus from the outset has been to improve the multiplayer user experience and to look closely at the social interactions that occur as users ask one another for help, at the kind of help asked for and received, and at the results of such help seeking and help giving experiences. So the constructive interaction protocol was used as a way to set up the study in order to focus, instead, on the interactions that occur as people use a multi-user system. It should also be noted that all users were co-located, that is, located next to one another and sharing the same console game system and television, but each with their own independent game controller.

The primary data source in this study was the series of 24 two-hour game play sessions, videotaped using two video cameras - one to capture the on-screen game play and the other to capture the facial expressions and gestures of the participants. The video data were analyzed with regard to the help giving and help seeking activities that occurred during game play. Examples of help giving and help seeking activities that were found include instances of both solicited and unsolicited game play advise about strategies, on-screen objects, game controller button combinations, etc, as well as how participants represented game play help to one another through physical gestures, verbal explanations, avatar/player character movement, etc.

(3) CSCW: Informal help-giving in the workplace (Twidale, 1999)

The purpose of the study was to investigate informal help-giving in the workplace. The main focus was on colleagues asking colleagues for help, rather than designated technical support staff. A variety of different workplaces were studied in the public and private sectors, including a financial institution, a clinic, a public library, a university library, a manufacturing design group, an agricultural outreach organization, and a newspaper.

The approach used various techniques from ethnography, including workplace observation, videotaping and post-incident interviews. An observer in the workplace would map out typical interactions, and pay particular attention to episodes of help-giving. After an incident, the participants were asked to describe the process, using the applications and other resources employed in the help-giving process. Help giving incidents were identified and analyzed and the episodes coded. Interviews asked about the episode from the perspective of the participants, the techniques used in resolving and explaining the problem, to what extent they 'solved' the problem, whether it was a sub part of a larger ongoing problem solving episode, and whether it related to other episodes not directly observed (Twidale, 1999). The episodes were analyzed in terms of the pedagogical techniques used, and the degree to which problem-solving was required in addition to knowledge transfer. That is, in the latter case the help-giver knows the solution to the help-seeker's request and can just focus on how best to explain what to do given the constraints of the situation, whereas in the former case the help-giver does not immediately know the answer and so has to both uncover a solution and explain it.

Results and Discussion

Forms of Spontaneous Collaboration

The results from these three studies indicated that spontaneous collaboration did happen in these contexts, which were not overtly designed or intended for collaboration. In the classroom, both the computer/game design and the teacher's rules dictated a single-user mode. Aside from emerging fields such as CSCL, much of our computer culture is individual-oriented: computer systems are designed for a single user (Scaife, 1989) and marketed as such (e.g., "the *personal* computer"). Both of the programs that the students chose to play, *Nanosaur* and *Putt-Putt Saves the Zoo*, were designed for a single user on a single computer. Furthermore, computers are often treated as the "teacher's machine" in the classroom, and their usage is often limited to assisting teachers' instruction (Zhao, Tan, & Mishra, 2002). The students in this classroom could use the classroom computers for work or games only during "choice time," which was between 2:00 and 3:00 p.m. from Monday to Thursday. The teacher also set up strict rules for computer use in this classroom, as follows: only two children were allowed on a computer at a time, every child had only five minutes at the computer, there was to be no watching, and other children had to write down their names on the waiting list and wait their turn using the timer. The "no watching" rule imposed the greatest challenge for students' group play at the computer. As revealed in the interview, the teacher felt strongly against crowding around the computer and watching:

> I don't value just grouping around the computer in the same way that I don't want them to just chase around the room. It seems pointless . . . It is passive. It is. I think the opportunities for negotiation and collaboration in other activities are far richer than just standing around the computer.

The teacher did not view "watching" the game as a viable choice. She thought the students were just watching mindlessly without making a choice. When she took away the student, she would often say "come, make a choice." In a way, she made the watching behavior often observed at Computer 1 completely illegitimate. She thus set a rule to limit the number of computer players to two. She explained, "Probably the chaos of that bothers me." The teacher's desire to avoid chaos by limiting the "grouping around" is understandable.

Based on the computer design and the teacher's rules, the intended practice at Computer 1 should have appeared as in Figure 1. There was only one computer with two students who had legitimate turns and who could sit in the two chairs in front of the computer.

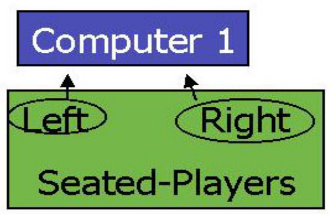

Figure 1. Intended practice at the computer.

We named students who occupied this position at any given time the "seated players[1]." Although the teacher allowed two students at the computer at a time, the rules clearly tried to maintain manageable collaboration. According to the teacher's rule, the student in the left seat was designated as the official player, while the student on the right was supposed to be watching.

Despite the intended use of Computer 1 according to the game design and the teacher's rules, children often collaborated and played a single-user game as a group. The following is a typical episode, transcribed from videotape, of students collaborating in this first-grade classroom to play *Nanosaur*.

[1] Seated players are marked by underlines in transcribed episodes.

[Episode 1. Group playing *Nanosaur*][2]

Ted sat in the left chair manipulating the keyboard while Victor was half-sitting in the chair on the right (his right foot was on the chair). Greg (standing to the left of Ted) had just finished his turn and stayed playing. Nick was watching the computer from the carpet next to the computer while holding Math Safari in his hands (he had signed up for the math activity).

Victor: There is the map! [pointing to the right corner of the screen]

Greg: That means we didn't pass [shaking his head], so go forward.

Victor: [stroking the keyboard]

}

Ted: [hands off the keyboard, just watching]

Nick: [pointing to the screen] There is some health down there.

Greg: No, there isn't anything. Go forward [pointing to the screen]. That's it. It is actually . . .

Victor: [pressing the key]

Greg: [pushing away Victor's hand and trying to type himself] No, go forward.

Ted: [pushing away Greg's hand and trying to get the keyboard back] No!

Nick: See, I told you there is health. [pointing to the screen]

Ted: There is no **health**.

Victor/Greg/Nick: Yes, there it is!

}

Eric: [looks up from his assignment and watches the computer from his table about nine feet away from Computer 1]

Ted: It looks like it is a follower from where it stands.

Tom: [approaches the computer and writes down his name on the waiting list on the small table next to Computer 1. He then stays behind Victor's chair watching the game.]

Greg: See, now you can . . . you don't get to die.

In this episode, in addition to the two seated players -- Ted (left) and Victor (right) -- four other students -- Nick, Greg, Tom and Eric -- were also involved in playing *Nanosaur*. Nick and Greg were active, making suggestions and even trying to get on the keyboard, while Tom simply approached the computer and Eric watched from afar. To different extents, they all contributed to the ongoing game and were engaged in a heated

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[2] Transcription conventions

//…//	events in the background
[ ]	actions/body movement of the actor
( )	the researcher's notes
=	pause
bold	verbal stress
Nick	an underlined name indicates a seated player
Victor	a name without underlining indicates a mobile participant
}	overlapping utterances/actions

discussion of the game. As a result, the actual practice that emerged around the computer is illustrated in Figure 2.

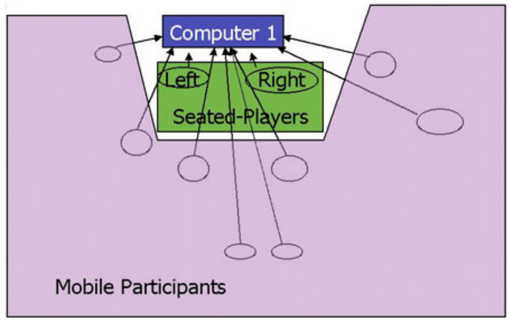

Figure 2. Actual practice at the computer.

In this diagram, a whole new group emerged and gathered around the computer (i.e., Eric, Nick, Greg, and Tom), whom I refer to as “mobile participants” because they too are participating but they mill around, moving in and out of the group and being unable to sit down in the official chairs. During any computer session, mobile participants might include children who continue playing after their turn is over (e.g., Greg), those who come to put their name on the waiting list or check their place on the list (e.g., Tom), those who directly approach the computer from another area of the classroom, or those who watch the computer screen while ostensibly working on another activity at the carpet area next to Computer 1 (e.g., Nick) or at a table far away (e.g., Eric). It was common to find that some students, who played at the other end of the classroom, were attracted by the sounds or images of ongoing games or the cheering of the group at the computer. They then became mobile participants by observing from a distance or giving up their own activities and coming close to join the group. While these mobile participants are highly fluid in their involvement, the seated players are relatively stable, numbering only two and typically staying the entire five minutes allotted to each of them by the timer (if not more). As a result, the students expanded the physical boundary of computer activity. The space was no longer confined to two chairs and the computer, as shown in Figure 1. It extended to the rest of the classroom and went as far as the other end of the classroom.

In the console game playing context, the college students helped each other even when they were in a competitive mode in order to have a more interesting game by narrowing the ability level gap between different players. The following is an example of students playing “Halo” a first-person “shooter” style game in cooperative mode. They need to figure how to make their characters duck under a door.

> [Episode 2. Playing in a cooperative mode]
> Danielle: [laughs] I’m thinking about tricks, you know? When I used to play Super Metroid…
> Sara: [experimenting with different buttons] This is ridiculous though. We aren’t even doing the point of the game.
> Danielle: Yeah but we are trying to figure out how to duck here. Ok Sara, I’m gonna pause the game.

[Changes mind and doesn't pause the game because Sara is still experimenting]
Ok, well you just keep doing it. I don't think there's a time limit.
[Danielle then picks up the game manual]
[Reading out loud] A melee attack. Really.
[Sarcastically] Ok. Crouch. Left thumbstick button, press in. [Looks down at her controller] Oh! [puts down the manual]

Sara: What? [looks down at her controller and puts thumb over left thumbstick] This thing?

Danielle:[Reaches over the Sara's controller and presses down on Sara's left controller thumbstick]
Push this thing. [She continues to press the left thumbstick on Sara's controller]

Sara: Whoa. Yeah! [They both successfully duck under the stuck door and move to the next section in the game level that they are in.]

The pair have already tried many other approaches including looking for solutions that avoid having to duck under the door. Danielle considers techniques from other applications that might help. They worry about time limits affecting their exploratory learning. Danielle finally consults the manual, figures out what to do and shows Sara.

In the workplace study, people were asking for help to solve an immediate need. They were not taking part in a designated learning activity or using designated learning time. Instead, the collaborative learning that occurred was interleaved with ongoing work.

[Episode 3. "Can you show them to me?"]

Sue: Where did you get the specifications from?
Can you show them to me?

Jared: [took over the mouse and keyboard and pulled out the information that Sue was asking for.]

Sue: Hey , how did you do that ?"
I have never used that, what was it?

Jared: Oh this is just a function from here, you go to the menu, type in the option and you get this results, its a very straight feature.

Sue: Cool, I will use it.

This is part of a larger interaction where Jared had asked Sue for help in solving a design problem with a CAD system. In the process of trying to understand the details of Jared's problem, Sue sees Jared obtaining the information she asked for in an unexpected way. She asks about it, and Jared repeats his actions more slowly so that Sue can follow them, describing them as well. Having obtained more of the details from Jared's design, Sue went back to her own workstation to look at some similar work that she was doing. She came up with a solution and walked back to Jared's desk, took over the mouse control and keyboard control again and pulled the files that she wanted on his computer herself and then made some changes to the figure and then she told him "This is how it should be". However, after a while Jared realized that he did not understand how Sue had solved the problem, so he went over to her desk with a notebook and pen while Sue explained to him what she had done, without resorting to a computer.

Social Goals and Task Goals

Results from all three studies indicate that the spontaneous collaboration was driven or constrained by participants' task goals and social goals. In the play study, the college students showed two competing task goals. On the one hand, the players wanted to win the game. But on the other hand, the players also wanted to have a competitive game. To win the game, the player should advance as much as they can and time-criticality played a role, particularly in the competitive game play modes. Sometimes to keep the game competitively interesting, one player, often the more seasoned videogame player, would slow down to shorten the distance between the two players. This would give the less experienced player a chance to catch up so that more "action" between the players could occur. Other times, the players would engage in "trash talking" – when players would insult one another and/or their skills at the game. This was often accompanied with a form of help giving, albeit a harsher version. For example, one player might say "what an idiot – haven't you figured out that it's the 'a' button to shoot?" Trash talking was found in both the competitive and the cooperative game play modes. Bridging the gap between player skill levels – which sometimes would take the guise of one player "waiting" for the other and sometimes would take the guise of an insult – can contribute to the social goal of having fun with friends (i.e., collaborative play).

Similar dynamics also played out in the classroom; to achieve the goal of advancing the game, participants should just let the expert play and the less experienced player watch, however the social goals of getting along with others motivate the whole community to collaborate to advance together. The data indicated that the roles children inhabited during a given turn session greatly impacted their apparent goals, but all of the children had some goals in common, whatever their role. Many of the children's goals hinged on the important tension between the seated players and the mobile participants, as in the following example.

> [Episode 4. "Only Victor and I are playing"]
> Jack was the first one to choose Computer 1 and he had just started the computer. Victor signed up for Computer 1 too.
>
> Victor: [approaches the computer and leans on the chair on the right]
> Nick: [approaches and stands next to Jesse on the left]
> Jack: Does it . . . (unclear)
> Victor: [pressing the keyboard] No, it doesn't. Go there.
> Nick: [pointing to the upper left corner of the screen] Here he (the character) is!
> Greg: [approaches and puts both hands on the back of Jack's chair] What are you playing, guys?
> Nick: Haha, he is turf.
> Victor: Shh, go away! [turning to Nick]
> Jack: Guys, only Victor and I are playing!

Victor: [sitting down on the right]
Nick/Greg: [step back and stand about two feet away from the computer]

Individually, the students' goals seem fairly obvious in this exchange. The seated players have a strong stake in the official turn structure while the mobile participants have obvious desires on joining the game. Jack and Victor, as the seated players, fiercely resisted Greg's and Nick's presence. Jack made a clear statement ("Only Victor and I are playing!") to emphasize the fact that he and Victor were the legitimate players at that time. Thus, Jack and Victor clearly formed an alliance. Victor kept policing Greg and Nick's attempts to join by invoking the "no watching" rule. Despite their repeated attempts, Jack and Victor successfully protected their space.

After multiple viewings of many exchanges like this one and after examining the children's apparent goals, I organized them according to the students' individual roles, their status as seated players or mobile participants, and their membership in the collective group around the computer and in the classroom as a whole. The seated players have the common goal of protecting their legitimate turns and their interactive space from the mobile participants; however, seated players also have different goals between them. The left player has a simple goal to prolong his or her time on the computer, while the right player has to make sure the turn-taking moves smoothly, in order to eventually secure his or her own turn. The mobile participants have more complicated goals, because their participation at the computer is not legitimate according to the teacher's rules, so they have to find a way to circumvent the rules and participate in the game play.

Although there were different goals for different roles and positions, all the goals can be classified into two types. The first focuses on the game playing goal, which often resulted in collaboration between the seated players and among the seated players and mobile participants. The game playing goal was, simply, to play the game for as long as possible and reach its highest level. The second classification type focuses on the children's social goals: belonging to the group, having fun with friends, and forming and consolidating friendships. As Crook (1987, p. 50) suggests, "the characteristic patterns of interacting *with* computers may serve to organize distinctive patterns of interacting *around* computers (social interaction)." These two kinds of interaction correspond to two types of goals that may not always align with each other. For example, when the goal of maintaining turns at the computer became stronger than the goal of advancing in the game, the seated players would try to push away mobile participants. When advancing in the game became the priority, however, the seated players would invite the mobile participants to participate in playing.

The goals were formed and continued to evolve in the process of playing at the computer. The goals shifted when the children's roles changed from being the right-seated player to being the left-seated player and from being a mobile participant to being a seated player. The goals also evolved as a child became more skillful in one game. At the beginning, a less skilled player tried to learn as much as possible and would welcome help and suggestions. When the player became more skillful in the game, he or she would want fewer suggestions and help from others. Children often had to reconcile their goals through their negotiation process.

In addition, these goals were affected by the affordances of the environment and by the social rules, yet at the same time these goals motivated the children to take different actions to achieve their goals. Sometimes the use of artifacts in the computer space, such as the arrangement of the computer and the two chairs, the timer, and the waiting list, were also in conflict with the children's goals. For example, the computer as an intelligent and interactive artifact greatly attracted the children and motivated them to form strong game playing goals. At the same time, the "no watching" rule limited their access. To reconcile this gap, they actively negotiated their social practice to achieve their game playing goal and generated different forms of games of the moment.

In the workplace, collaborative problem solving involves a complex mapping between the workplace goals (what the help seeker wants to do as part of their job, say compose, format and print out a report), and the capabilities of the available technologies, and the understanding and skills of the various people involved. Considerable satisfying work was done that relied on the detailed shared contextual understanding of the participants. For example, a request about how to do a particular kind of formatting in Microsoft Word can lead to a proposed solution that does not actually fulfill the request, but does satisfy the overall goal. The help-giver may not know how to do the exact formatting requested, but if she knows enough about why the help-seeker wishes to do that formatting (say to produce the monthly sales report so that it looks acceptable), she is able to propose a workaround using a quite different feature in Word, or even by copying and pasting from a different application. The focus on the real work tasks can allow satisfying, but only if the participants understand those tasks. A technically far more knowledgeable help-giver who understands the work context less well (say a provider of telephone technical support) would be unable to suggest acceptable workarounds. Furthermore, the help-giving and learning needs to be integrated into the 'real work'. Therefore it needs to be fast and focused. Leisurely learning experiences may be desirable, but just not feasible or appropriate. Unlike classroom learning contexts, ideal learning should be initiated and completed in just a few seconds or minutes. The most extreme case we encountered of such hyper-efficient learning was between two colleagues in offices opposite each other. One shouted across a question about how to do something in Microsoft Word and the other shouted back a single word. That was the term used in Word to denote the formatting concept in the menu hierarchy. With that one word, the help-seeker was able to identify exactly what to do. There is a clear etiquette to help-seeking, at least as observed in our studies. The help-seeker's request would include some mention of what they had tried to do themselves. The attempt and failure to solve the problem on one's own, including trying the 'obvious' steps seems an important part of the help-seeking ritual, in some sense justifying the interruption of a colleague's work to ask for help.

It should be noted that there is a clear sampling bias in this study. We explained to the organizations and their participants that the aim of the study was to investigate informal help-giving. As a result, only organizations that were positively disposed to peer help-giving would be likely to grant us permission to study them,. It is quite possible that many organizations actively discourage help-giving as a 'distraction from proper work'

Appropriating Rules and Tools

In the process of collaborating with their peers in the context in which the collaboration was not the main focus, participants intentionally or unintentionally bent the rules and appropriated the artifacts to support their efforts.

The way that college game players bent their level of play to achieve their competitive goals is a good example. This kind of social "rubber-banding" is not designed in the program. In the case of game-playing, one can consider a design technique called "rubberbanding" where, in a single player game, AI computer opponents might be "forced back" by the program if it's too far ahead of the human player, as if being snapped back by a rubberband. In the case of a multiplayer game, an example of social versus programmed scaffolding would be where a more expert player might pause for a minute in a race to allow their competitor(s) to come closer to them to make the game at hand more challenging.

In the classroom, the students adapted a game designed for single user to accommodate a group of players. They divided the control of keyboard and mouse among themselves, with onlookers actively involved in strategic decisions, albeit sometimes unwelcome. As discussed earlier, the two main programs that the students chose to play were *Nanosaur* and *Putt-Putt Saves the Zoo*. While both games were designed for a single user on a single computer, the first-graders in this classroom appropriated the software to serve their group needs and goals – playing with their friends and having fun together. They transferred these two games to accommodate at least two players. *Nanosaur* is a good example. The game allows the user to map input to either the keyboard or the mouse. However, the students decided to use the keyboard and mouse separately by two seated players. Thus, the player on the left was no longer a passive observer as intended by the teacher's rules, and the seated players could play together by coordinating their action as seen in the following example.

> [Episode 5. "You jump, I'll count"]
> Katie and Greg were playing *Nanosaur* together. Katie sat on the left and had the keyboard while Greg was on the right, controlling the mouse.
>
> Greg: This is the way you can fly it. [pointing to the left side of the screen]
> Katie: Ok, now I am gonna try a way to fly. [excitingly standing up and looking down on the keyboard]
> Ha, ha . . . it just starts jumping! [busy pressing on the keyboard]
> Ok, I've got an idea. OK, you jump, I'll count [pressing keys].
> Greg: Okay!
> Katie: Jump! Jump! Jump! (very fast) [nodding her head and leaning forward]
> I count 3, jump. 1, 2, 3, jump! [very busy pressing the keys]
> [sitting down]
> Greg: That [pointing to the screen] Oh, no! (disappointed)
> Yes, yes, go sideways. [signaling the direction on the screen]
> Katie: What's happening now?

Greg: Yeah, that way. (You are) very close (to the hot lava). It happened to Victor and me.
Katie: Why?
Greg: Oh! (excitedly) Go that way! [pointing to the left on the screen]

In this episode, Katie and Greg were involved in the intentional coordination of their actions on the keyboard and the mouse. Katie devised a “counting” scheme while Greg happily played along. Although it did not seem to work well because the pace of the game was so fast, it nevertheless indicated the seated players’ explicit efforts to coordinate their actions. Through many exchanges similar to this, such as “tell me when you need me to jump” or “now, you jump”, seated players successfully played as a team. By separating the functions of keyboard and mouse and coordinating their actions, the students made the single-user program an authentic two-player game.

In the workplace, the participants appropriated various resources to help identify the underlying cause of the problem or confusion and so work to a resolution. These include the computer screen as a shared tool for diagnosis (a purpose for which application interfaces are not consciously designed), as well as paper, printouts, manuals and other people in the office or nearby. In the case of the engineering company, many of the help-giving interactions involved discussions of a three dimensional element constructed using a CAD system. Getting a sense of the 3-D structure of the actual design and discussing and thinking about how it might be changed seemed to be particularly challenging. A variety of techniques were used to support thinking about and discussing issues with a 3-D component. These included sketching ideas on paper, gesturing with one hand acting out the role of the design and being rotated in space, using a small model that was somewhat like the designed artifact, using a pen to stand for the artifact being discussed, and most noticeably to us, constantly moving the 3D CAD design on the screen. Naturally the screen is itself two-dimensional and contains a 2D representation of the 3D model. To maintain a sense of the three-dimensionality of the actual design, the moving of the design rotates it in virtual space and this is represented by the constantly changing two-dimensional projection on the screen, which appears to support the ongoing discussion about the artifact.

In an office study, other people were brought into support the practice of certain techniques with an email program. In order to practice and clarify the distinction between forwarding, copying and redirecting, the help-giver called on two other colleagues to send messages to the help-seeker, and report on successful receipt of the help-seeker’s actions. This was easy to do because all the participants were in an open plan office.

Interleaved Play, Work and Learning

Other convergent results indicate the embedded nature of learning. In all three situations we have cases of learning embedded in other activities. In workplace learning, the main focus of people is to get their work tasks done, but when problems are encountered, people ask colleagues for help and advice. In the case of playing a competitive console game, the main focus is to have an enjoyable time by competing, but if one’s opponent is far less skilled than you are, you may need to help them learn enough to have an enjoyable time and be a more challenging competitor. In interacting with peers and waiting one's turn to play a game in a classroom, children seem compelled to help each other improve

The interleaving of the pairs (work & learning and play & learning) leads us to wonder about three-way interleaving. Do games have a component of work in them? Does the playing of games have implications for work? Does workplace learning have a playful component in it, or if not, should it? The last question does seem particularly surprising. Learning a feature in MS Word does not appear to be as much fun as figuring out how to get to Championship Level in Tennis 2K2. However, the informal help-giving interactions that we saw often had some aspects of playfulness about them. Sometimes it was a break from routine work, or a chance to interact with a colleague as a change from solitary work. Sometimes social interactions (greeting people as they arrived or passed by) turned into a request for help. Nardi (1993) notes that even mundane work related applications such as spreadsheets led to the emergence of local developers who chose to spend more time 'tinkering' (a term implying playfulness); learning about the technology and interacting with programmers.

There is a growing body of research on issues of play or fun and its relation to computer use (Pagulayan, Steury, Fulton, & Romero, 2003). Some of this work looks at informal use of computers either as games or as part of everyday non-work life. Others explicitly address the question of whether we can or should draw on computer games as inspiration for workplace tools, particularly to support the learning of those tools (e.g. Carroll, 1982; Draper, 1999; Neal, 1990).

The short, spontaneous and unplanned learning is embedded in the participation in meaningful community practice. The results also challenge the artificial distinctions among play, work and learning. In three different contexts, we have witnessed blurred distinctions. Game play can readily change to learning how to collaborate with your peers and negotiating group participation. Or the other way around, work can also transformed to learning a skill with your co-workers. Learning can be playing and having fun with your peers. If the studies are representative of widespread computer use, as we believe to be the case, then this carries significant design implications both for built-in support for learning (such as help systems and tutorials) as well as for wider learning infrastructures of manuals, training etc. We explore this more in the next section.

<u>Agency in Technology Rich Environment</u>

It is also important to note that main action is on this side of the computer screen. Although the computer is the focal point in all three contexts, the realization of the use of the technology depends on participants' actions and group dynamics. The interaction between human and computer is supported by human-human interaction. At the same time, the interaction between people is also mediated by computers. People learn through their interactions with the computer as well as their interactions with others around the computer. However, two research fields that have been exploring this issue--Human-

Computer Interaction (HCI) and Computer Supported Collaborative Learning (CSCL)--break it down to two seemingly separate pieces. HCI researchers look at the dynamics between computers and human beings, while CSCL moves the focus from computer-human to human-human interactions. Sociocultural theory advocates study should begin with "a unit of analysis that includes both the individual and his/her culturally defined environment" (Wertsch, 1979, p. viii). This project represents an effort to study these human-human-computer interactions.

In the case of the workplace studies, the interactions occur because of a breakdown. The individual user was trying to accomplish something and failed, or had done an action and got an unexpected result. The ensuing interaction involves both discussion between the help-seeker and the help-giver, and interactions of either or both with the application. However the interaction with the application is subtly different from the intended use of a single user accomplishing a task. In the help-giving interaction, firstly the help-giver may need to use the application to work out how to do the task, a form of search and problem-solving around the available options and commands within the application (or indeed involving the coordination of several applications), and secondly a pedagogic interaction in order to show the help-seeker how to accomplish the task. This pedagogic interaction might be a demonstration by the help-giver with a running commentary, or involve the help-seeker being talked through the interaction sequence, but executing the steps themselves. In either case, the use for learning how to do a sequence of steps is different from conventional use just to do the steps. The learning sequence is slower, accompanied by commentary, and may need to be interrupted for greater clarification. As a result things can go wrong given that usually the system has no 'awareness' of this different kind of use. For example, the help-giver may use the mouse to hover over a drop-down menu in order to discuss its contents with the help-seeker. The interface is being used rhetorically – to illustrate the human-human conversation. But the application does not know that. It is easy for the help-giver's rhetorical use to involve a slip that actually is interpreted by the application as a command while the intention of the speaker and mouser was to just talk about the use of the command.

Implications

This project combines studies in three different contexts help us better understand an overlooked phenomenon: spontaneous collaboration. It illustrates its presence in very different settings and with different participants. It has potential implications for educators, workplace managers, and computer and software designers.

Based on the study, teachers can change their rules and redesign the classroom to facilitate students' spontaneous collaboration while managers may reconfigure the help-giving system and integrate the spontaneous help-seeking and giving into their work system. For example, the teacher can implicitly encourage group interaction by arranging classroom computers in an open space, which allows more students to join the group and more visual access from distant parts of the room. The teacher can also place more chairs in front of the computers. If there is more than one computer in the classroom, the teacher can position computers next to each other, so that students can discuss their work and games as they play separately. Teachers may also pair students with different expertise at the computer to maximize their collaboration. In addition to structuring the physical environment, teachers can use the opportunities provided by students' spontaneous collaboration at computers to explicitly involve students in the process of constructing classroom rules and norms. Engaging students in discussions such as what is an appropriate computer turn length, how many players make up the optimal group size at the computer, what are proper behaviors during group play at computers, etc. will afford students opportunities to further consider these complex social issues. Additionally, when students help develop the classroom rules, they share ownership of classroom norms and will likely be more willing to self-monitor and follow these co-constructed rules (Cobb, Wood, & Yackel, 1993). The teacher can also encourage a classroom discussion about individual goals, group goals and how they are related to their communal experience in the classroom. For example, unlimited group play at the computer may well serve the group's goal to have fun with their friends, but if the group play is so loud as to disturb other students, how should the group goals be adjusted to serve the needs of the whole class community? I have argued that the phenomenon of collaborative computer use provides situated opportunities for students to explore issues of social negotiation and classroom agency. Teacher-led discussions such as those that I have suggested, however, have the power to bring these issues to the forefront, make them explicit, and thus scaffold children's social-cognitive development even further.

The program designers can improve their game or program design to accommodate and facilitate this kind of spontaneous collaboration. Key features to support are representations of process history (what has been tried so far and how a particular task involves a sequence of steps), and representations of possible alternate sequences (what might be tried next, what the different possibilities to try are, and which one will be tried out first). Note that these functionality needs are distinct from skilled operation, which we would claim is what current interfaces are designed to support. In skilled operation, the user knows what she is doing and wants to do and needs no support to stop and reflect on the process. Rather she just wants an interface that lets her act out the process as efficiently as possible. By contrast, to support learning of how to use an application, or how to use an application better or how to use an application differently for slightly different needs, we should consider how to build in explicit support for reflection and discussion of the process of use, not merely optimize that use.

We have noted that there are various ways in which people appropriate the application, and indeed also use external resources such as pens, paper, manuals and other people to support different ways of learning by employing different pedagogical techniques. Such techniques are discussed in detail in the general educational literature and particular manifestations of those techniques are developed and analyzed in the educational computing literature. Pedagogies related to collaborative learning are further explored in the Computer Supported Collaborative Learning (CSCL) literature. Our point is that thinking about how to help someone to use an application should not just be a concern for the educational computing world. Even within educational computing, a consideration of application learning can be swamped by the far more prominent concern of using a computer to learn something else. The learning of the application itself needs to be a concern for all application developers. Learning how to use the actual application is a need not just for a CSCL system developed to help high school students learn about genetics, but also for a complex online fantasy game, an application for families to share digital photographs, or one to enable an insurance company to process complex claims. Fortunately the techniques developed and analyzed in the educational literature and illustrated by the examples in this paper can help. We are not claiming that there is one right way to learn a particular application. Different people will try different techniques depending on the overall context and what seems to work. Indeed in one sense the application developer need to nothing. As we have shown, people appropriate application use to enable the learning of those applications by others. But it is worth considering how we as designers might help that process (Dourish, 2003), given that the overall learnability of the application may be a contributing factor to its acceptance (Grudin, 1994).

We believe that the issues identified have a number of implications for systems and interface design. In the case of games, the grandstanding and running commentaries could be associated with features to support the commenting process, drawing on the kinds of actions done by TV sports reporters' use of action replays, selections of significant clips, annotations, use of statistics etc. More advanced features would involve completely separate interfaces (and most likely separate displays) for the players' and the commentators' creation of public displays and representations. Thus the players may focus in on the game interface while the commentator takes that feed and manipulates it as a TV sportscaster takes in and manipulates multiple camera feeds of a live sports broadcast. Asynchronous possibilities include the creation of edited highlights and compilations to show to others (including the original players), and to share these with others not present when the game was actually played. There are already examples of communities doing just this kind of activity. For example players of Quake create run-throughs of levels to illustrate their prowess. Such run-throughs can also be used to illustrate gameplay or strategies to other members of their gaming community. An example of such a community can be found http://www.planetquake.com/qdq/news.html.

In order to help a competitor gain skills, something like a training session may help. In this, the trainer wishes to select or create a scenario that will enable the learner to practice a sub-skill without the complexity of distracting additional work. Alternatively, they may want to set up the circumstances in which a rarely used skill is necessary, without having to go through a conventional game scenario from scratch where many other actions have to be performed before the skill is exercised. Many games, especially sports games, have a practice mode for a single player. However we are not aware of games that make it easy for two people to set up a training mode where a more expert player can show a novice player some critical skills without a game play penalty (i.e., showing the other player a skill that puts the game at risk for one or both players). An example of this might be a training room where players of a fighting game could spar against one another with no time restrictions or move that ends the game (unless, of course, the players choose to end the training themselves). Another example might be a skate park where players can teach one another basic boarding moves while not competing for trick points and/or racing each other. Isolation exercises are a common part of training, particularly for complex kinesthetic skills that have aspects of time criticality. This applies for example to sports, dance, playing a musical instrument, or learning to drive a car. In an isolation exercise, only part of the total activity is practiced at a time, with various techniques employed to enable the separation out of the particular activity to be concentrated on and practiced. After isolation exercises, the learner can then return to practicing the integration of all the necessary components of the activity.

For workplace help-giving, we are investigating supplementary interfaces for supporting discussion of a help-giving interaction. These have some interesting parallels with the game situation outlined above. Most help-seekers attempted a solution themselves before resorting to asking for help. However describing exactly what has been tried can be difficult, especially for non-expert computer users who lack specialist terminology. Mechanisms for recording and representing the process of a sequence of actions can support discussions of what has been tried so far, what might be tried next, and when a solution has been found, creating a record of what to do for future use (Favorin & Kuutti,1996). Explorations of complex solutions occur when the help-giver is unsure of the solution, and wishes to experiment safely. This can be done by a skilled computer user, but greater support for experimental, exploratory use, as compared with efficient use for regular tasks would help many users. The distinction parallels that between ‘practice mode’ and ‘compete mode’ in games.

For CSCW applications in particular, practice modes may need the easy creation of multiple dummy logins for participants who are not taking on their official roles. It can help if some of those can be simulated, so that a practice session with 8 way communication can be achieved by just two or three participants. In the school, a greater sensitivity to shared use may impact application design, such as options for splitting activity smoothly between keyboard and mouse, or between two sides of the keyboard (Inkpen & her colleagues, 1995; 1999). Other options might be to create scenarios for an extra person to take on a monitoring role to issue suggestions to the players actually directly interacting with the keyboard. These options do not radically change the activity and could still be a (perhaps more challenging) single user application. However they create the potential for suggesting ways to open up the application to larger numbers. Perhaps the most important implication is less for application design than for curriculum design. We would wish to emphasize to teachers the different kinds of learning and social interaction that do already occur around such games in such situations, and to encourage consideration of these wider lessons of helping, turn-taking and the organization of group behavior. These are important skills for young children to be learning and the organization of fair play around the game is worth considering as a ‘teachable moment’ rather than as an annoying, potentially disruptive and educationally lightweight play option.

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