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Social Construction of Computer Experience in a First-Grade Classroom: Social Processes and Mediating Artifacts[1]

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X. Christine Wang and Cynthia Carter Ching

University of Illinois at Urbana-Champaign

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Correspondence regarding the article should be addressed to X. Christine Wang, Department of Curriculum and Instruction, College of Education, 1310 S. Sixth Street, Champaign, IL 61820. (Email: x-wang12@uiuc.edu)

Abstract

Based on a Vygotskian perspective, as well as a broader socio-cultural perspective, we propose a transactional model of social processes and artifacts to investigate young children's social construction of their computer experience. An ethnographic study was conducted in a first-grade classroom at a public school located in a Midwest town. A grounded-theory approach was used to analyze video, field notes, interviews, and artifacts. The results indicate that young children constantly negotiate between their own individual and collective goals in the classroom and the affordances of the environment, as they create their own definition of computer use while simultaneously conforming to the rules set by the teacher. The artifacts students use— the computer, a timer, and waiting lists-- both enable and challenge children's social negotiation. In this negotiation process, children socially construct not only their computer experience, but also their early school experience on a whole. The transactional model provides a useful theoretical framework to study children's social practice as well as practical suggestions for teachers to optimize students' collaborative interaction.

Social Construction of Computer Experience in a First-Grade Classroom: Social Processes and Mediating Artifacts

In early childhood classrooms where computers remain limited resources, children are often observed spontaneously forming a group around a computer, with one or two children controlling the keyboard and the mouse while others mill around and move in or out of the group, contributing suggestions or comments to the ongoing activities (e.g., Davidson & Wright, 1994; Freeman & Somerindyke, 2001). The following is a typical episode, transcribed from videotape, of students collaborating in a first-grade classroom to play a computer game.

> [Episode 1] It was choice time in this first-grade classroom. Students were working on their chosen activities while the teacher moved around the classroom to assist or monitor the activities. Two chairs were placed in front of an iMac computer. Bill sat in the left chair and manipulated the keyboard. Kevin sat on the edge of the chair on the right and leaned toward the computer screen while clicking on the mouse with his right hand. Greg and Nick stood behind Bill's chair and looked at the screen. Ted was writing down his name on the waiting list on the table next to the computer desk. Victor, holding a big doll on his head and humming a song, entered the computer space from another end of the classroom.
>
> Nick: [He turns to Victor and reaches out to touch Victor's doll. He then turns back to the computer screen immediately.]
>
> Ted: [stepping close to the computer and turning to Greg] Did you put your name (down on the waiting list)…
>
> Greg: [ignoring Ted and speaking loud] Anyway, we're not, we're not changing anything…
>
> Kevin: Jump, jump, jump! [clicking on the mouse]
>
> Greg: We didn't change anything.
>
> Victor: [attentively watching the screen] We don't even do that.
>
> Kevin: Ooh, you're there, you're there! (excitedly)
>
> Nick/Ted: [Echoing Kevin's excitement] You're there, you're there!
>
> Nick: [pointing to the screen] Go in there, heee!
>
> Kevin: Oh, the best bullet is gonna shot you.
>
> Victor: No!

Ted: Yeah!
Victor: Don't get them , don't get them
Ted: Yeah, they will kill you.
Kevin/Nick/Victor: Yes, they do.
Greg: Here, use your health…
Bill: OK!
… Their discussion and the group play at the computer continued.

In the example above, five children were involved in the play of *Nanosaur*, a computer game in which the users maneuver a dinosaur to its quest for saving eggs of different species of dinosaur. Both the children who were seated in the chairs and those who stood behind them were very animated, and all contributed to the development of strategies for successful game play. Their collaboration was intense, with highly overlapping talk, and also somewhat loud. This type of activity may appear as chaos and a failure in classroom management to some classroom teachers, a computer design problem (the computer system doesn't accommodate multiple users) to computer engineers, or a waste of computer time to educational researchers because the students are "just playing games." From a Vygotskian perspective, however, the picture changes significantly: the children are engaged in valuable social construction and negotiation of their classroom experience and culture by appropriating and transforming the use of a powerful cultural artifact; in this case, the computer.

It is important to understand how young children negotiate their experience and transform artifacts during spontaneous group collaboration at computers for three reasons. First, young children often must work together, because most schools do not have enough computers for each student to use individually (Lomangino, Nicholson, & Sulzby, 1999); thus, the logistical reality makes spontaneous group collaboration a valuable issue to consider. Second, early childhood is the age when children are developing critical ideas about technology, collaboration, the meaning

of school, and their place in the social order of school (Papert, 1993). These ideas are important to prepare children to become productive members in the increasingly technological and globalized world (Turkle, 1984). Finally, the insights gained from an investigation of children's spontaneous group collaboration will help teachers and computer designers better understand the complexity of children's work at computers and give them suggestions for optimizing the affordance of computers for collaborative interactions. These suggestions are much needed, considering that computers are increasingly introduced in early childhood education programs (Sarama & Clements, 2002).

This study also addresses some holes in the fabric of existing research. Most studies adopting a sociocultural perspective toward educational technology (such as a focus on scaffolding, collaboration, etc) deal with older student populations, advanced learning in academic domains, and almost all use technology as a tool to scaffold skills and knowledge-building in content areas such as science and mathematics (e.g., Davis, 2003; Hmelo & Guzdial, 1996; Hoadley & Hsi, 1996; Sandoval, 2003). Many studies also largely ignore the classroom community and conveniently define "children-at-computer" as a bounded and visible physical setting for study (Crook, 1999). Furthermore, as argued by Granott (1998), most of these studies focus on fixed groups (often dyads) assigned by teachers or researchers. The current study, on the other hand, investigates group computer use by first-grade children within their classroom culture by focusing on the social processes and mediating artifacts they employ to develop norms for collaborative computer use, and how, via this process, they socially construct their own roles as active agents in their classroom.

Transactional Model of Social Processes and Artifacts

To analyze children's spontaneous group interaction at computers, we propose a transactional model of social processes and mediating artifacts based on a sociocultural perspective, derived from the writings of L. S. Vygotsky (1978, 1981, 1987) and neo-Vygotskian scholars (e.g., Cole, 1996; Leont'ev, 1981; Wertsch, 1985, 1998). Sociocultural theory establishes that children's learning and development are the process of socialization into cultural activity within specific environments (Cole, 1996). But this is not a one-way socialization. As Vygotsky (1978, p. 51) argues, "it may be said that the basic characteristic of human behavior in general is that humans personally influence their relations with the environment, and through the environment personally change their behavior." Thus it is crucial to examine not only how children are affected by the social environments in which they find themselves, but also how children shape these environments as active agents.

In order to understand the relationship between children's learning and its cultural, historical and institutional settings, mediational means—social and discursive practices as well as materials and tools—are crucial (Cole & Wertsch, 1996; Wertsch, Tulviste, & Hagstrom, 1993). Cultural artifacts not only facilitate our activities, but also enable and determine the nature of the activities, as Vygotsky (1981, p. 137) stated, "the psychological tool alters the entire flow and structure of mental functions." At the same time, the meaning and use of cultural artifacts are structured and transformed through activities. This transformation is mediated by the artifacts' affordances. Affordance is defined as the perceived and actual properties of an artifact, which determine possible uses in a particular context (Gibson, 1977; Norman, 1988).

A sociocultural approach also extends the notion of children's agency beyond what we normally consider "a property of the individual" (Wertsch et al., 1993, p.336). Rather, cognition

is socially distributed among members of the community where individuals find themselves (Hutchins, 1991; Lave & Wenger, 1991). Thus, it is important to study children as members of a community. As active agents in the classroom, the children's motives, goals, and agendas affect how they interact with others and the surrounding cultural artifacts, while simultaneously these same artifacts affect children's goals and agendas. It is this reflexive relationship that we offer for examination in this study.

To put all these concepts together, we propose a transactional model of social processes and mediational artifacts[2] (see Figure 1). First, we believe that young children are active agents who constantly construct their social context. It is important to examine children's cognitive and social goals as both individuals and members of a group. Second, the affordances of computers and other artifacts, as well as classroom rules for social and collaborative interaction at computers are essential to understanding how the artifacts both affect and are affected by children's social practice at the computer. Finally, social practice here refers to children's social interaction when they spontaneously form groups at the computer. According to the model, social practice is the result of negotiation among children's goals and intents, affordances of the cultural artifacts, and the social rules in the classroom. At the same time, children also reshape their goals and appropriate and transform the affordances of the cultural artifacts through their social practices.

Social Practices and Children's Goals

Studies on young children's socialization in their natural environments—at home (e.g., Rogoff, 1990), daycare centers (e.g., Corsaro, 1985; 1997), preschool (e.g., Fernie, 1990), and

[2] This model applies to this specific study that focuses on group dynamics at the computer. We expect the model will be adjusted with further investigation of issues such as gender, race, and other individual differences, which are beyond the scope of the current study.

elementary schools (e.g., Carere, 1987)—echo a common theme: children actively construct their social context. Even in teacher-centered classrooms, children and teachers continually negotiate relative autonomy, rules for order, and constructed meanings of spatial-temporal classroom characteristics (Kalekin-Fishman, 1987). Children take an active role in appropriating and transforming the meanings of their immediate environments by using the cultural tools available to them, even displaying resistance at times to the highly structured and constraining demands of the institutions in which they sometimes find themselves (Carere, 1987).

To understand children's autonomy and active roles in their social practices, Saxe (1991, 1992) proposed the "emergent goals framework." This framework holds that children construct and evolve their problem-solving goals as they participate in practice-linked social interaction, they appropriate artifacts in their efforts to conceptualize and solve problems, and they familiarize activity structures and bring in their prior experience and understanding. This framework has proved useful in studying children's problem-solving goals and how goals are constructed and shifted during play (Guberman, Rahm, & Menk, 1998; Saxe & Guberman, 1998). Saxe's model does not address, however, how children reconcile different goals in social interaction (e.g. social goals vs. competitive goals), or consider collective goals that may be shared by a group of children. Many studies indicate that there is a wide range of social goals when children work together (e.g., Corsaro, 1985; Dyson, 1993). Lomangino et al., (1999) specifically identified a number of social goals that guided first-grade children's collaborative interaction during computer use: maintaining equality and fairness among peers, appearing competent to peers, asserting control over others, and maintaining their relationships with others. Our own attention to children's negotiated goals, and how this negotiation is realized through social practices and mediating artifacts, is influenced by this existing research.

Social Practices and Mediating Artifacts

In recent years, a growing body of research places artifacts and their affordances at the heart of an analytic agenda for both sociology and cognitive science (Heath & Hindmarsh, 2000). Interestingly, the most well-known studies of cognition and artifact use do not include the context of school. Oceanic navigation (Hutchins, 1995), dairy work (Lave, 1988), and weaving (Rogoff, 1995) are all practices which have been analyzed with an eye toward the semiotic mediation of cultural artifacts and how participants socially negotiate and appropriate those artifacts to serve activity-centered goals. Children's learning in schools has not received as much attention from an artifact perspective, with a few notable exceptions (Saxe, Dawson, Fall, & Howard, 1996; Saxe & Guberman, 1998; Sfard & McClain, 2002). Most of the studies conducted in school settings focus on artifacts for math and science learning, such as inscriptions (e.g., Cobb, 2002) and graphic manipulatives (Sfard & McClain, 2002). Yet the everyday artifacts that are present in classrooms, those that are not unique to a particular academic domain, even mundane objects like desks and chairs, also shed light on the nature of knowing and doing in these communities (Dewey, 1920).

The computer as a cultural artifact has many features that set it apart. Computer use has been shown to affect motivation, engagement, and sustained attention among elementary students (see review Krendl & Lieberman, 1988), an effect that lingers over a long period of time after computers are introduced to the classroom (Bergin, Ford, & Hess, 1993). A distinctive feature of the computer is its physically self-contained nature (Crook, 1994) and its usual function as circumscribed screen-plus-input devices. This self-contained nature, together with an interactive quality, sustains students' interest and keeps them busy. Consequently, computers

tend to attract less teacher intervention and leave more freedom for children to explore on their own compared to other cultural artifacts in the classroom (Crook, 1994).

Many studies focusing on the social process at computers have documented rich and productive peer interactions (e.g., Dickinson, 1986; Dillenbourg, 1999). Regarding these processes, however, there is a lack of a satisfying explanation about what creates a successful collaboration with computers (Littleton & Light, 1999). Some more recent studies suggest that the computer's capacity to help externalize mental representation (Scaife & Rogers, 1996) and to help articulate ideas is the key to its role in peer collaboration (Crook, 1994). However, Roschelle and Teasley (1994) argued that articulation of ideas is naturally afforded by a socially organized task.

Studies of collaboration with and around educational technology have revealed many ways in which the computer as a classroom artifact can support collaborative learning, support cognition, and foster motivation and engagement. We are not aware, however, of any studies that examine the ways in which spontaneous computer collaborations can support children's social construction of classroom agency and norms for technology use. Further, we are not only interested in the circumscribed computer *per se*, but also in the host of other related artifacts that comprise a whole system of mediation in the classroom computer space, and in the ways children collaboratively negotiate and appropriate these artifacts toward further social ends.

Research Questions

We entered this investigation initially with one overarching question: What kinds of social practice occur when children spontaneously form groups around a classroom computer? Given both authors' interest and training in sociocultural research, early childhood education, and computer-supported collaborative learning, these multiple perspectives were brought to bear

in our fieldwork for this study. The following more specific questions, and the transactional model that frames them, thus emerged in the process of continued engagement with this project: What kinds of social agenda/goals affect children's social interaction at the computer? What are the affordances of the physical and social environment for children's collaborative interaction at computers? How do children negotiate between the affordances of the environment and their individual and collective goals? Finally, how do children appropriate and transform artifacts to serve their negotiation needs? The fieldwork and the processes of forming and addressing these questions are described in the following section.

Method

This is a classroom-based ethnographic study undertaken to understand the nature of social processes and mediating artifacts in children's computer use with peers, as situated within their current curriculum and class culture. Applying ethnographic research methods, and particularly grounded theory methodology (Strauss & Corbin, 1998), we approached the data collection and initial viewing with a broad research question about the nature of students' spontaneous collaboration; further research questions about children's activity goals, artifact affordances, and mediational processes emerged from continued engagement with the data collected and were informed by the literature reviewed in the previous section. Before we address the analysis process that led to the formation and answering of those questions, however, we first describe our research site and participants and our methods for gaining access and data collection.

Research Site and Participants

This study was conducted in a first-grade classroom at a public elementary school located in a Midwest town. Based on 2001 school data, there were 21% African-American, 5.8% Asian-

American, 1.5% Hispanic, and 70% White students. The students are mainly from working and middle-class families, of which 37% are from low-income families and eligible for free lunch. The average class size for first grade is 18 in the school and the 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. A total of 14 children's parents gave permission for their children to participate and to be videotaped. They are the primary participants. Based on an initial family survey, all the 14 participants had at least one computer at home. Two of the children did not use a computer at home at all. Of the children who used a computer at home, they played educational games an average of 15 to 30 minutes per day.

The secondary participant is the classroom teacher, Linda[3]. Linda had five years of teaching experience and a Master's degree in early childhood education. In general, Linda had a positive attitude towards technology and computers. She felt comfortable using computers herself and was interested in integrating computers into her teaching; however, she did not see herself using computer in a "truly integrated way," as she revealed in an interview. As a result, there was no explicit computer curriculum. The computer was used in the classroom primarily as an enrichment or free-choice activity for students.

Contexts for Computer Use in the Classroom

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 and was loaded with more recent games such as *Nanosaur*™ (a dinosaur adventure game) and *Putt-Putt*

[3] All participants' names are pseudonyms.

Saves the Zoo™ (a problem-solving game). The students were observed using Computer 1 most of the time; occasionally Computer 2 was used by those students waiting to use Computer 1. Consequently the majority of data collected and analyzed for the present analysis is focused on interactions around Computer 1.

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. Choice time began when the teacher wrote activity choices on the blackboard and then randomly pulled students' names from a mug. The selected students would one by one put their nametags under the activity they chose. The choices included Computer 1, Computer 2, writing, reading, drawing, painting, manipulatives (such as counters, pattern blocks, etc.), math enrichment, picture-taking, and other activities related to ongoing projects such as a weather survey and weather experiments. Computers 1 and 2 were among the few choices that limited participants to a maximum of two at a time. A timer was used at Computer 1 to limit each student's time to only five minutes. Those students not being the first to select computers as their choice activity had to then sign up on a waiting list and do other activities while waiting for their turns. Sometimes not all children on the waiting list got an official turn. Students developed innovative ways of getting around this turn-taking system, however, as we will show later.

Fieldwork and Data Sources

The fieldwork for this study lasted an entire school year and went through three stages: gaining entry, establishing rapport, and collecting data. Fieldwork and classroom visits occurred two to three times a week on average. The first author had an earlier acquaintance with Linda through a writing project and informal visits to her 2nd grade class the year before, which facilitated the entry. During initial visits, Corsaro's (1985) "reactive" entry strategy was used,

namely not initiating interaction but instead reacting to children's initiated interaction. Throughout the fieldwork, the researcher collecting data assumed a role of participant observer (Le Compte & Goetz, 1984), at first being more active in cultivating the "friend role" of research (Fine & Sandstrom, 1988). This role involved helping the classroom teacher from time to time with passing out handouts, helping students' with math and reading, or watching the class when the teacher ran errands in the building. During this initial period of time, fieldnotes and official data collection were kept to a minimum—reflections were only recorded away from the research site. After the students and teacher became accustomed to the researcher's presence in their classroom, a video camera was introduced, and observation and video taping began.

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. In the process of collecting video data, a grounded theory approach was followed, which prescribes an ongoing dialogue between data analysis and further data collection. For example, the video camera solely focused on the space immediately surrounding Computer 1 at the beginning, but initial analysis of videos and field notes indicated that the interactions were not confined to this space. Sometimes children jumped into the discussion at the computer from far away because they had been watching from a distance. To adjust to the redefined focus, the camera was repositioned focused it on a wider space around the computer. The camera did not appear to distract children who were at computers; they were always highly engaged in computer activities with their peers. The camera did cause some excitement for those who walked around the computer looking for something to do, but this novelty effect wore out rather quickly toward the end of the third week of taping.

Gradually, the camera blended into the physical environment and appeared to cause little intrusion.

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 (such as the daily waiting lists and choice-time logs), and interviews mainly complement and triangulate video data interpretations. These data helped the researchers situate the video within the whole classroom context.

Interviews with the students and the teacher were used to gather the participants' points of view and to triangulate the researchers' interpretations. Formal interviews with each student took place during choice time in an area that was relatively quiet and separate from the rest of the classroom. Each interview lasted about 15-20 minutes. The interview session was videotaped to capture both verbal and facial/body language. The interview questions focused on the children's views and their perceptions of peers, computers, rules for computer use and their interactions at the computer. Three formal interviews were also conducted with the teacher. The initial background interview, conducted in the first week of the school, gathered background information on the class, the students, the curriculum, computer activities, and the teacher's view of computers and peer interaction at computers. The other two formal interviews were conducted at the end of the school year. The teacher interview protocols were developed partially based on previous informal face-to-face talk and email communications and included themes such as general classroom culture and rules, the teacher's role at the computers, rules for students' computer use, choice time, and the role of computers in students' learning.

Data Analysis

During the first stage of data analysis, we mostly followed the interaction analysis approach to deal with the video data. We 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).

We 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 stage of data analysis, we mainly dealt with transcribed video sessions. Segments were selected for transcription that reflected routine activities and patterns, as well as variability in those patterns. We applied grounded theory, a method of iterative dialogue between emerging frameworks and data analysis, to develop an interpretation and theory of children's socially constructed computer experience in the classroom. We used students' negotiation of rules as an example to demonstrate the analysis process. We developed different conceptual coding categories such as rules at the computer, rules set by the teacher, rule violating, rule enforcement, and rule negotiation. We applied the constant comparison technique (Strauss & Corbin, 1998) from grounded theory to compare these categories across different sessions. We also examined the interviews for proof or contradictors; for example, the teacher's enforcement of the rules recorded in the video occurred far less often than she stated in her interviews. Instead, the students who didn't get their turn on the computer often enforced the

teacher's official rules. We thus adjusted the category of "rule enforcement" to include students' and teachers' enforcement.

When we examined the relationships among our conceptual categories, there were often apparent contradictions. For example, we saw big gaps between the official rules and rules actually enacted at the computers. There was a "no watching" rule designed to limit the number of students clustered around the computer at any given time, but students eventually started coming to the computer corner by checking the waiting list, working in the carpet area next to the computer, or watching from far behind. Thus many students could be present in the area and watch without seeming to watch. This contradiction became one of the emerging foci of the study: how did children move from the official rules to the enacted rules at the computer? What motivated their modifications of the official rules? At first we hypothesized that computer play was inherently motivating for these children, and that students thus wanted to play or observe whenever they could.

The testing of the theory and interpretations was guided by a theoretical sampling technique (Strauss & Corbin, 1998). We sampled additional episodes to find confirmations or contradictions. Interestingly children crowded around Computer 1, while rarely did anyone play at Computer 2, so our prediction about the inherent attraction of computers needed adjustment. The interview data indicated a possible reason-- that Computer 2 didn't have enough interesting games, but a peer debriefing session pointed to a different hypothesis: young children like to play together, and simply getting to play at Computer 1 was not their only motivation. Playing at Computer 1 basically became a social event in which everyone was part of the group that tried to reach a higher level of the game. This adjustment of our hypothesis then greatly changed our interpretation of socially constructed computer experiences. We continuously made comparisons

between the explanatory adequacy of the theoretical constructs and these additional empirical indicators until theoretical saturation was reached (i.e., additional analysis no longer contributed anything new about a concept). In this way, our resulting interpretations, of which the discussion of rules above is only one example, can be considered conceptually dense and grounded in the data.

Means to Warrant Trustworthiness of Our Analysis

In addition to vigorously applying Interactional Analysis and Grounded Theory approach, we 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 ours. 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 we applied to achieve trustworthiness. We showed videos to fellow researchers and other classroom teachers and exchanged and discussed our interpretations. Our interpretations were solidified or challenged and adjusted through those debriefing sessions. Through all these methods, we thus feel confident that the results we will describe in the next section are valid and robust.

Results

The transactional model we proposed—of children's social practice emerging from agents and artifacts, as mediated by social negotiation and artifact transformation and appropriation — and the research questions specific to that model, guide the organization and presentation of our results. Rather than working through the model top-down, however, we present results in an organization that illuminates our ethnographic process: beginning with the social practices we initially observed during spontaneous group formation, then describing

children's individual and collective goals and the affordances of surrounding artifacts (both physical artifacts and social rules) that became apparent during our grounded theory guided investigation, and finally revealing the mediating process of children's social negotiation among these elements via appropriating and transforming artifacts to serve their needs.

Social Practices in Spontaneously Formed Groups around the Computer

Evident from the very beginning was that playing computer games during choice time was a highly desirable activity for the children. All the choice time logs and observation notes indicate that every day the first two students selected at random to choose their activities always chose Computer 1. There was not a single exception, even during the days when the teacher introduced new activities. The results from the interviews also confirm children's strong interests in computer activities. Twelve out of the fourteen total students rated Computer 1 as their favorite choice-time activity. For the two students who did not rate Computer 1 as their most favorite, Computer 1 was among their top three favorite choices.

As is often the case in most school settings, however, computer availability in the classroom was not sufficient to meet this high demand. There were only two computers in the classroom, and one of them (Computer 2) was almost unusable due to a slow processor and a limited number of programs available. The teacher's rule allowing only two children at the computer at a time further limited children's access, in principle. But the children always found a way to get around this rule. The data indicate that for 70% of videotaped computer time, there were more than two children clustered together at the computer. A typical computer session would be as follows: two children sat in chairs in front of the computer controlling the keyboard and mouse, while two or three other children stood behind them and pointed to the screen or offered suggestions. These standing children would often move in and out of the area and

occasionally be replaced by others. Consider the following excerpt as an example of this grouping pattern.

> [Episode 2] Ken sat in the left chair in front of Computer 1 and started the program *Putt-Putt Saves the Zoo.* Victor sat on his knees on the right chair and looked at the computer screen, while Nick wrote his name on the waiting list on the table to the left of the computer. Eric entered the computer space from another area of the room.
>
> Eric: [approaching the computer] Are you playing *Nanosaur*?
>
> Victor: [turning around] There is no *Nanosaur*, Eric!
> [pushing Eric] Go away.
>
> Eric: [says nothing and moves to stand behind Ken.]
>
> Ken: [turning around] You can't play *Nanosaur*.
>
> Nick: [leaning toward the computer] Why?
>
> Ken: Because there's too much violence (unclear)…
>
> The program *Putt-Putt Saves the Zoo* started with loud music.
>
> Victor: [pressing the keys to lower the volume] Too loud, Ken!
>
> Ken: I know! I know! (impatiently)
>
> Nick: [pointing to the apple key] Push the fast button, dude!
>
> Ken: [pushing away Nick's hand] Oh, yeah.
>
> Nick : [pointing to a different key] That one!
>
> Eric: No, No. [pushing Nick away and pressing the apple key himself]
>
> Victor: [pushing Eric] Quit, Eric! (annoyed)
>
> Nick: [pointing to the apple key again and shouting to Ken] Push that button!

In this episode, Ken and Victor are two legitimate computer users. We call students who occupy this position at any given time "seated players[4]," because students with legitimate turns could sit in one of the two chairs in front of the computer. According to the teacher's rules, the student in the left seat was designated as the official player, while the student seated on the right was supposed to be observing. In our example, it was technically Ken's turn. In actual practice, however, seated players always worked together. The others who gathered around the computer

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

(e.g., Nick and Eric) are referred to as "mobile participants," since they too are participating, but they mill around and cannot sit down in the official chairs. During any computer session, mobile participants might include children who came to put their name on the waiting list or check their place on the list (e.g., Nick); or those who directly approached the computer from another area of the classroom (e.g., Eric); or those who watched the computer screen while ostensibly working on another activity at the rug area next to Computer 1 or at a table approximately six feet away. 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).

This grouping pattern, in which as many as five or six children participate in the computer activity at once, sharply contrasts with the dominant individual-oriented computer culture. Computer systems are generally designed for a single user (Scaife, 1989) and marketed as personal (e.g., "the personal computer"). In this classroom the children created a unique group-oriented computer norm. As is obvious from the example, however, this grouping was not always amicable. At times the seated players seemed to appreciate the presence of mobile participants (e.g., Ken acknowledges Nick's suggestion to "push the fast button") whereas other times, often during the same turn session, exchanges between seated players and mobile participants were more antagonistic (e.g., pushing and saying, "go away"). In searching to reconcile these apparent contradictions, we examined the individual and collective goals that children had when playing at Computer 1 and how these goals motivated their behavior.

Individual and Collective Goals at the Computer

We noted that the roles children inhabited during a given turn session greatly impacted their apparent goals, but all children had some goals in common, whatever their role. Many of

children's goals hinge on the important tension between seated players and mobile participants, as in the following example.

> [Episode 3] Victor and Kevin were playing *Toy Story* at Computer 1. Eric had been quietly standing behind Victor's chair and watching for a while.
>
> Kevin: [standing up and crossing his legs] Stop! Stop! Don't play a game coz I need to go to the bathroom. Don't let people play.
> [gives Eric a warning look before running to the restroom]
>
> Eric: [murmuring to Victor from behind] You're losing.
>
> Victor: [pushing away Eric] No, I am not. Now, go away!
>
> Eric: [avoids Victor and stays behind his chair]
>
> Bill: [approaching to the left side of Victor] Is anyone playing with you?
>
> Victor: Kevin.
>
> Eric: He's taking a pee, I'll watch it here. [taking Kevin's chair next to Victor's]
>
> Victor: [looking around for Kevin] Can we start now?
>
> Bill: [leaves]

Individually, the students' goals seem fairly obvious in this exchange. The seated players have a strong stake in the official turn structure. Kevin wants to protect his turn as the player in the left chair and tries to enlist the other seated player, Victor, in this effort while he runs to the bathroom ("don't let other people play!"). Victor also wants to protect the official turn structure, since it is his turn next after Kevin, but another goal is playing the game as soon as possible ("can we start now?"). Eric, a mobile participant with obvious desires on becoming a seated player, reminds Victor of an additional goal unrelated to the turn-taking rules: continued progress in the game ("you are losing," and "it is speeding up"). Bill, another mobile participant, is also interested in becoming a seated player ("is anyone playing with you?"), but his additional goal to follow the rules is apparently stronger, since he leaves after discovering that both seated player spots are taken, despite Kevin's temporary absence.

After multiple viewings of many exchanges like this one and examining the children's apparent goals, we organized them according to 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 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 are different goals for different roles and positions, all the goals can be classified into two types. The first is the game playing goal, which often results in collaboration between seated players and amongst the seated players and mobile participants, as in Episode 2 when Nick suggested using the "fast button." The game playing goal involves playing the game for as long as possible and getting to the highest level. The second classification type is social goals: socially 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 as Victor did in Episode 3. When advancing in the game became the priority, however, the seated players would invite the mobile participants to participate in

playing as seen in Episode 4. We also found there were some gender differences in this aspect. Girls tended to focus more on the social goals than game playing goals, which was evident when comparing all-girl pairs to all-boy pairs as seated players. A thorough analysis of gender differences is beyond the scope of this particular paper, however, and will be dealt with in later reporting.

In addition to the goals shared by the seated players and by the mobile participants, the whole group has some common goals: play the game to the highest possible level, minimize the teacher's intervention, maximize their playing time, have fun, socially belong to the group at the computer, and be good students in the classroom. Depending on one's status as a seated player or a mobile participant (thus going against the teacher's rules), the "good student" goal may be in conflict with the others. Students thus had to negotiate tensions between their goals and the rules of participation as set up by the teacher. Sometimes the use of artifacts in the computer space themselves, such as the arrangement of the computer and two chairs, the timer, and the waiting list, were also in conflict with children's goals.

Affordances of the Physical and Social Settings around the Computer

We distinguish the artifacts constituting the physical space around the computer from the social rules regarding computer use in the classroom, but focus jointly on their affordances for collaborative interaction. We identified key artifacts as Computer 1, two chairs placed in front the computer, waiting lists, and the timer. The software programs in use are also important artifacts; however, it is beyond the scope of this paper to discuss software affordances.

The artifacts in question both enable and constrain collaboration and interaction. The two chairs placed in front of Computer 1 enabled at least two children to participate in the computer activity and encouraged their collaboration. On the other hand, these same chairs limited

participation beyond two children who could comfortably access the keyboard and mouse. As a result, children who stood behind the chairs sometimes tried to type on the keyboard and faced rejection from the seated players. The computer itself also has mixed affordances for collaboration. Computer systems are designed for a single user with one screen and single set of input devices. This poses a challenge for collaboration and interaction with more than one user. At the same time, the easily visibility of the computer screen and audible sound system in our classroom made participation available to those children who were not directly in front of the screen. They could see and hear what was going on, even from the other end of the classroom. The waiting list, while making the groupings less spontaneous by imposing an order on who was able to play when, also created a legitimate reason to come to the computer area, in order to sign up or check one's position. One constraining affordance of the timer was to cut off the flow of play at a pre-determined time, unrelated to game progress or natural pauses in the action; however, the timer also helped to ensure fairness and equity in terms of turn length.

The classroom rules for computer use also had mixed affordances for collaboration and interaction at the computer. In addition to the aforementioned rules limiting the legitimate users to only two at a time and the five-minute time constraint, there were other rules as well. A constraint that was invoked far more often by the students than the teacher, the "no watching" rule explicitly prohibited other children from observing the computer without an official turn; however, fewer mobile participants watching the entire process meant that seated players could prolong their turns without enforcement from those waiting to supplant their official status.

As revealed in the interview, the teacher felt strongly against crowding around the computer and watching, as she stated "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." 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 "grouping around" is understandable. Again, however, stated practices and our video data did not match up. In all video episodes, there were only five out of 30 occasions on which the teacher reminded mobile participants to choose other activities. When asked about this discrepancy, she explained it as due to oversight: "It's according to what I am doing at that time. If I am working closely with someone, I may not see it." Most of the enforcement of classroom computer rules, then, fell to the students themselves. This combination of constraints and liberties put the children in a curious position of negotiating between conforming to the teacher's definitions of appropriate behavior and being free to create a unique peer episode (Mendell, 1986). The rules existed to constrain certain behaviors, yet often students could ignore, or bend, or rigidly enforce these rules as they mutually agreed, through moment-to-moment social negotiation, to do so.

Social Processes of Negotiating Goals and Affordances of the Environment

As we described earlier, children's goals and the affordances of the environment are not always aligned with each other. To achieve their goals, children in our study constantly negotiated the limits of the setting. In our video data we identified several social patterns of students negotiating amongst one another and the affordances of the environment. These patterns have different variations depending on the situation and participants. Given the limitation of the article length, we only present two patterns with rich description and analysis: delimitating physical boundaries and streamlining the turn taking mechanisms.

Delimiting physical boundaries. All children observed around Computer 1 shared the goals of getting on the computer and playing with peers. But finding the best way to attain these

goals posed a challenge for mobile participants. Pushiness could result in complete rejection by the seated players, but patiently waiting one's turn would not be rewarded if choice time ran out before the waiting list had been exhausted. Thus mobile participants had to find ways of judiciously increasing their participation. Flexibly delimiting the physical boundary of computer use is one example of how students negotiated between these goals and the affordances of the setting.

As described previously, children were often observed watching the computer screen from a desk several feet away or from the carpet area next to the computer. This behavior was not limited to passive observation, however. Students often scrutinized the computer activity intently from afar and waited for an opportunity to join the action, as in the following example.

> [Episode 4] Jack and Carrie were playing *Nanosaur* together with Jack controlling the direction of the characters on the keyboard and Carrie moving the mouse to do different stunts – jump, kick, turn etc. Greg stood about two feet behind them but attentively looked at the computer screen. Jack and Carrie hotly discussed their game.
>
> Jack: I need some bullets.
>
> Carrie: Ok! [clicking the mouse]
>
> Greg: [moves one step closer to them]
>
> Jack: I need to get to the hot lava! Hot lava! [impatiently typing]
>
> Greg: [moving up one more step and using his hand to signal where to go on the screen] Go sideways!
>
> Here it is. [nodding after Jack followed his direction]
>
> Jack: There's water and health. (happily)
>
> Greg: Yes, there is.
>
> [looking around toward other activities in the classroom]
>
> Jack: Why can you go faster …(unclear) water?
>
> [turns around and realizes that Greg is not there]
>
> Greg, how do you…?
>
> Greg: [rushing back to the computer and pointing to the screen where to go next] Go sideways, please! Please go sideways, that's the way!

> Greg then stood to Jack's left and gave more suggestions. From time to time, Greg even put his hands on the keyboard and played himself.

Here Greg moves closer to the game-playing action by scooting forward one step at a time. He then gives directions to the seated players, Jack and Carrie, still from a few feet away ("go sideways!"). After Greg's suggestion proves very useful for continued play of the game, Jack wants to enlist Greg's help further. Jack turns around, expecting to see Greg immediately behind him, and is surprised that Greg is farther away. Jack then calls to Greg directly ("Greg, how do you…?"), at which point Greg rushes into the immediate computer area and takes a more official, albeit standing, position. In this episode, we see how the different goals of the seated players and the mobile participants were in this case compatible. Jack and Carrie wanted to succeed in the game, and Greg wanted to play with them. Through their talk and social negotiation, both parties helped to create a flexible boundary around the computer to serve their goals—Greg by inching up closer (but not too close) and offering help, and Jack by implicitly inviting Greg to come all the way over to the computer. Through many other interactions like this one, the children transformed the meaning of the area around the computer, such that it became a highly significant space with shifting zones of participatory legitimacy.

There is a range of variations of this pattern depending on the distance of the participants from the computer corner. Prior to and during Episode 1, presented at the beginning of the article, the mobile participants – Greg, Nick, Ted, and Victor-- approached the computer area differently. Greg and Nick intentionally chose to play with math manipulatives in the carpet area next to the computer. They gradually moved to the computer game by watching first, offering suggestions from time to time, and finally giving up their chosen activities and joining Bill and Kevin's game play. Ted approached the computer corner with a legitimate reason to check the

waiting list and put down his own name on the list. He then joined the group by asking Greg and Nick whether they had written down their names on the list. Victor, on the other hand, was pretending to be a family with several other girls in the storage area at another end of the room. He was attracted by the action at the computer and made up an excuse (the doll wanted to join his friends at the computer) to leave[5]. He then walked across the classroom to join the group as shown in Episode 1.

Streamlining the turn-taking system. The teacher's rules imposed rigid turn-taking at Computer 1. To reach their goals of game playing and having fun with their peers, the students streamlined their turn-taking system through social negotiation and by transforming the meaning of the two computer chairs and the space on either side. As described earlier, the teacher had initially set up the space such that the child on the left was the official player (with a legitimate turn) and the child on the right was the official observer. And, of course, in the teacher's rule watching and waiting were not allowed. Students negotiated among themselves to change this system. Over time, turn-taking evolved toward the following structure, as long as all seated participants implicitly agreed and did not invoke the "no watching" rule. The child on the left chair was the main player who had sole control of the keyboard and primary control of the mouse. The child on the right had less control of the computer, but this child was always involved in the ongoing activities by watching, suggesting, or sometimes manipulating the mouse. Mobile participants who were standing and waiting for their turns queued up to the right of the right seated participant. When the child on the left's time (5 minutes) was up, he or she would get up and leave the chair, but would occasionally stay and stand on the left to keep

[5] The first author observed Victor's movement from "the family" group to the computer. An informal talk with the girls in the group revealed Victor's excuse.

watching. The child on the right then moved over to the left chair while the next waiting child took the right chair.

By queuing up the turn-taking process, students minimized the disruption of the entire process, because the child on the right was already involved in the game and was ready to carry on where the previous child left off. The waiting child was also ready to take on his or her role as right seated participant, due to already being part of the activity by watching and commenting from a standing position. The same queue shift repeated itself in the next round. Thus turns progressed smoothly, with minimal interruption of the game action and progression toward the eventual winning goal.

As the video data indicated, streamlining the turn-taking system went through an evolving process. At the beginning, there was some confusion about whose turn was next. The student whose name was on the top of the waiting list would try to grab the chair on the left while forgetting the seated player on the right was also in the waiting queue. Even when there was no such confusion, the player on the right would sometimes bump into the waiting mobile participants when he/she walked around the right chair from behind and moved to the left chair. These accidental bumps and arguments about turns sometimes elicited the teacher's intervention. One day toward the end of the first month, Carrie moved up to the left chair without moving behind the chairs right after Kitty left, and Ken then took Carrie's chair from behind. This prototype of streamlining the turn-taking system was copied by the other students in next several turn-takings on that day and the day after. Gradually, the practice of queuing up the turn-taking became the norm at the computer.

Appropriating and Transforming Cultural Artifacts

The physical and social artifacts in the computer space and their characteristics imposed limits as well as opportunities for different interpretation and usage, as we discussed earlier. Not only are the artifacts themselves important, but also the ways in which students leveraged them to achieve different goals. Vygotsky and other sociocultural scholars have argued that semiotic mediation is the process whereby concrete tools and symbols are transformed into tools to think with (Saxe et al., 1996; Vygotsky, 1978). Thus although our computer-related artifacts have institutionally defined functions and purposes, they are also endowed by the students with uses and meanings beyond these; they become transformed into tools with which students' interests can be actualized. Similar to the social process patterns, the data also indicated a wide range of ways to appropriate these artifacts, depending on the situation and the participant's roles and goals. For example, the "no watching" rule was usually invoked by the seated players to protect their turns and space. But sometimes mobile participants would police themselves with the "no watching" rule to avoid too many people crowding around the computer. Due to the limitation of the length, in this section we only present in-depth analyses of several examples of how students appropriated the artifacts of the timer, the wait list, and the "no watching" rule to serve complex social negotiation functions.

Timer. The timer was introduced in the later part of the first semester. It took some time for the children to get used to it. The children initially hated the timer; their explanation was, "the timer takes away the time we can play." Gradually, they discovered that timer actually guaranteed a fair share of time at the computer, and after a while, all the children became used to the timer. Later in the year, some children figured out how to set the timer to more than the required 5 minutes, as in the following example.

[Episode 5] The timer went off. Carrie got up and left her chair. Nick moved over into the official player spot while Kevin was approaching the desk for his turn. Ted observed from farther away.

Carrie: [setting the timer to 9 minutes] Look!
Nick: [smiling and lowering his voice] 9 minutes!
Kevin: [takes the right chair without knowing the trick]
Ted: [approaching the computer and looking at the timer] What? 8 minutes? You're cheating!
Kevin: Give it to me!
Kevin took the timer and set it back to 5 minutes.

It was not uncommon for seated players to form an alliance and attempt to prolong their turns or keep out mobile participants. In the case above, Carrie attempts to maintain her alliance with Nick even after her turn as the official player has ended. She sets the timer for Nick's turn and stealthily shows him that she has given him an extra four minutes. Although the timer is designed to ensure equity, Carrie appropriates it for inequitable purposes. Interestingly, however, she doesn't use her knowledge of how to defeat the timer for herself. The timer becomes a means of doing a favor for another and is thus transformed to serve the social goal of building relationships. (Unfortunately for Carrie, however, her attempt is foiled by the ever-vigilant mobile participants.)

The wait list and "no watching." Our final example is a continuation of Episode 3. Recall that Kevin leaves for the bathroom, and Victor (the right seated player) is left to defend both players' official status and put the turn-taking system on hold until Kevin returns. As this situation continues, two mobile participants, Eric and Ken, appropriate the wait list and transform the "no watching" rule for rhetorical purposes, to convince Victor to give up his efforts.

[Episode 6] Kevin was still in the bathroom. Eric continued to sit next to Victor in Kevin's chair. Ken watched their argument.

Victor: [looking around for Kevin] Can we start now?

Bill: [leaves]

Victor: [to Eric] Go!

Eric: [turns his head away from the computer and pretends not to be watching the screen]

Ken: [walking to the desk next to the computer and putting down a piece of paper] I'm going to put down everybody's name!

Victor: [looking up from the keyboard to Ken] No, you cannot.

Ken: [ignoring Victor and writing, then reading aloud the names waiting for the computer] Kevin, Victor, Eric, Ken…

Victor: [turning to Eric again] Go, you are not supposed to be watching!

Eric: [putting his right hand on his eyes while watching through the fingers] I'm not watching, look!

Victor: [smiles at Eric]

Eric transforms the meaning of the "no watching" rule in interesting ways in this exchange. As the "no watching" rule was usually invoked, it meant that observers should "go away" and not crowd around the seated players; it typically was used as a means to define and protect the space around the seated players. Here Eric transforms the rule, however, and enacts it literally—by sarcastically turning his head away from the screen or covering his eyes. Despite the fact that he is ostensibly following the rule, Eric remains in the protected space of the seated players, even going so far as to usurp the official player's seat. Victor is both frustrated and amused by Eric's joke, but he obviously gets the point. Ken's use of the waiting list in this exchange represents an even more powerful rhetorical strategy. While Ken does not explicitly tell Victor that it is unfair to hold up so many others while Kevin is in the bathroom, his writing and subsequent dramatic reading of the waiting list serves exactly that function. Ken thus appropriates the waiting list and uses it to serve the complicated social function of challenging

Victor's action by appealing to the greater good (i.e., the others who are waiting, including Victor himself).

In summary, the students' social practices when they spontaneously formed a group at the computer were the result of ongoing negotiating between children's individual and collective goals and affordances of the environment including the cultural artifacts and the social rules in the classroom. Children reconciled their game playing goals and social goals as individuals as or a group, as demonstrated in the interaction among and between seated players and mobile participants. The artifacts and the rules comprising the activity of classroom computer use offered possibilities as well as challenges for children's social negotiation. In the process of social negotiation, they appropriated and transformed the norms of the artifacts.

Conclusions

Returning to the research questions we posed at the beginning of this study, we found that when children spontaneously form groups around a classroom computer, highly complex and sophisticated patterns emerge. Children continually negotiate between their individual goals, which may vary considerably depending on which seated player or mobile participant position they occupy at any given time, and collective group goals during computer play. Classroom rules such as limits on time and number of participants, and the structure of the physical environment such as computer placement and surrounding chairs, both enable and constrain children's collaborative computer use. These environmental factors provide assurances of fairness while also imposing structures on turn-taking and group work that are unrelated to game progress or children's collaborative tendencies. Children also negotiate tensions between their goals and the environment. This negotiation results in phenomena wherein children choose to invoke or ignore classroom rules (such as "no watching"), create new collaborative norms (such

as the queue), and impose meaning on the surrounding physical space (such as fluidly delimiting the boundary around the computer). Finally, we found that children appropriate artifacts in their environment in a kind of semiotic mediation to serve the needs of complex social negotiation, such as maintaining social alliances via manipulating the timer, or illuminating conflict between individual and group goals through a dramatic reading of the waiting list.

These findings speak volumes to the existing literature on educational technology use and early childhood education. Whereas the majority of existing literature examines older children and technology for academic subject learning, our findings show an in-depth picture of how young children using technology in the classroom are afforded multiple opportunities for social and cognitive development via their continual negotiations. Many existing studies define "children-at-computer" as the boundary for unit of analysis (Crook, 1999), whereas we have demonstrated that the physical space surrounding the computer and the activity of children in the periphery of that space are also crucial to understanding the phenomenon of children's collaborative computer use. Our study compliments the existing work on young children which demonstrates how they actively construct meanings in their environment, and extends these findings to the realm of educational technology use, an under-studied area in early childhood. Our study also responds to and builds on existing literature dealing with children's construction of goals during collaborative play (e.g., Saxe & Guberman, 1998) by examining goals that are shared by a group of children and investigating how children negotiate amongst competing goals in social interaction.

This study, and the transactional model of social process and artifacts that results from it, has special implications for applying Vygotskian perspectives to early childhood education. This model adopts and develops the notion that mediational means, including social and discursive

practices as well as cultural artifacts, are key to understanding the relationship between children's learning and development and their social and cultural settings. Our model captures the complexity of children's experiences as they define goals, make sense of both the physical and social worlds from their own personal and collective perspectives, edge their way toward working with others, and negotiate between their goals and environmental affordances. The model sheds light on how children make sense of their classroom experience by using cultural artifacts such as computers. It also highlights children's autonomy in manipulating and transforming the meaning of cultural artifacts and creating their own culture in the classroom. Although we only used it to examine children's socially constructed computer experience, we believe this model has broader applications in examining other social practices in early childhood classrooms or different settings.

Our findings lead us to some specific suggestions for teachers to optimize collaborative and productive interaction among students in general, and collaboration at computers in particular. It is important for teachers to understand children's social practice as result of negotiation between their goals and the affordances of the environment. Teachers can then try to restructure factors such as goals and the environment to encourage more collaborative interaction. First, teachers should be aware of the potential of cultural artifacts and social rules for facilitating or hindering collaborative interaction and accordingly re-arrange the physical environment or re-design rules. As demonstrated by our study, although computers are designed for solitary work, group work is highly desirable among young children, and there is room for collaboration at computers. 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. Our study demonstrated that students are well aware of the benefits and limitations of rules restricting time on the computer, number of legitimate participants, etc. Engaging students in discussions such as what is an appropriate computer turn length, how many players are 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? In this paper we 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 we 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.

We hope these concrete suggestions for practice will prove useful to early childhood teachers; however, there is a much larger agenda behind our work than the production of a "how to" kind of list. For both teachers and researchers, understanding children's interactions and activities from the perspective of children's individual and social goals, affordances of the environment, and the negotiation amongst these factors is of paramount importance. It is difficult to shift out of the prevailing objective models of classroom management, assessment of learning outcomes, or whatever the teacher or researcher preoccupation may be. Yet it is crucial to understand the world of children from their perspective, and be aware of the explicit and implicit influence exerted by the social and physical classroom environment. Teachers who use our findings as a lens to view their own classrooms can then apply this newfound vision to other activities besides computer collaboration. This study is in no position to offer a cookbook procedure for such a shift of perspectives and a change in practice, however, because these processes are highly contextual and embedded in each teacher's classroom, his or her students, and school culture. The literature on teacher education (Clift, Houston, & Pugach, 1990; Noffke, 1997) indicates that changes in practice only come through teachers' reflections and incremental evolution over the long term. We hope this study offers a springboard for teachers' reflections on children's interactions at computers. The specific issues teachers may encounter in their classrooms may be different from what we discussed in this study. As long as teachers try to see things from the children's point of view, however, they will discover inherent social and developmental value in many common classroom phenomena, which could be a valuable first step toward shifting perspectives and improving practice.

This study is just a beginning to explore how children interact when they spontaneously form a group at the computer within the classroom culture, and despite the strides and

implications described here, this study has definite limitations. As stated earlier, we focused exclusively on group dynamics, without a great deal of considerations for individual differences. Further studies on gender and individual differences will deepen our understanding of children's spontaneous group interaction. In addition, we only examined how the children's goals are affected by their immediate classroom environment; however, children live in different socio-cultural settings. The linkage with broader sociopolitical contexts, such as family and community, or the function of the school as societal institution will certainly affect children's agency and goals. Children's computer experiences at home, for example, would possibly affect their use of computers in the classroom. Thus, we believe that future studies extending our inquiry into students' family and school culture and investigating possible connections with their group-oriented computer culture in the classroom will shed more light on this phenomena. Finally, this study investigated computer game play during free choice time. Additional investigations at different sites should address children's spontaneous and structured collaboration during computer activities integrated into their classroom curricula.

Despite these limitations, we believe this study provides a unique approach in its application of Vygotskian perspectives to early childhood research and practice. Early childhood educators should look beyond traditional Vygotskian concepts such as "Zone of Proximal Development" and "scaffolding." Recent developments in sociocultural research have focused on semiotic mediation and the affordances of artifacts to facilitate and transform learning activities (e.g. Engestrom, 1987; Kuutti, 1996); such perspectives have yet to be incorporated into early childhood education research and more studies are needed in this direction.

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Figure

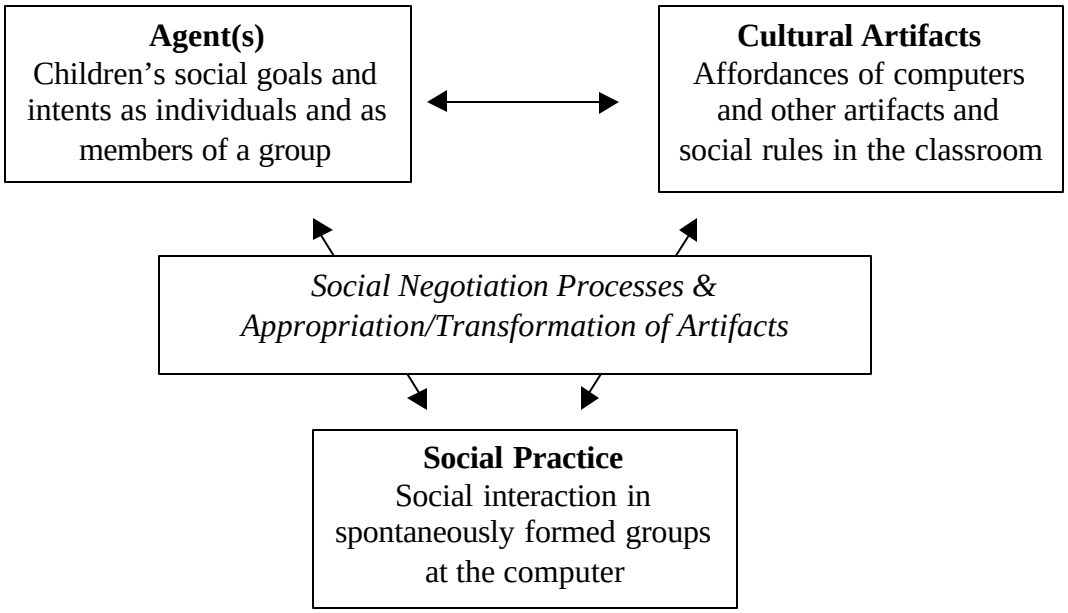

Figure 1. Transactional Model of Social Processes and Mediational Artifacts