How Activities Foster CMC Tool Use in Classrooms

Barry J. Fishman and Louis M. Gomez

The University of Michigan and Northwestern University

Abstract

This paper explores the relationship between CMC tool use and classroom activity cycles. Results of case studies of students in two high schools using e-mail, Usenet news, and a multimedia groupware notebook are presented. Findings indicate that teacher designs for classroom activity relate strongly to the frequency with which different tools are used.

Keywords—computer networks, research in technologically-mediated communication, design and interface issues.

Introduction

To date, relatively few studies have attempted to understand the role of collaborative communication technologies in classrooms. There are some notable exceptions: Schwab, Hart-Landsberg, Reder, and Abel (1992) studied how e-mail impacted the communication practices of middle school teachers. Levin, Kim and Riel (1989), and Levin, Waugh, Chung, and Miyake (1992) reported on calendar-based cycles in e-mail communications involving school students.

This paper reports on part of a larger program of research (Fishman, 1996) that tracked student tool use behaviors and daily activities in thirteen classes taught by six teachers. These classrooms were equipped with (by current school standards) high-end Internet connectivity and computer-mediated communication (CMC) tools. These tools included e-mail, Usenet news, and an asynchronous multimedia tool called the CoVis Collaboratory Notebook. The Collaboratory Notebook, described at CSCL '95 (O'Neill, Edelson, Gomez & D'Amico, 1995), is designed especially to support science inquiry.

Levin and his colleagues studied activity cycles in classrooms where electronic mail, a cornerstone CMC technology, was utilized. Research reports by Levin, et al. (1992; 1989) characterized the activity cycles of classrooms that participated in the Intercultural Learning Network (Levin & Cohen, 1985) and AT&T Learning Circles (Riel, 1989). They found that the ebb and flow of e-mail use in these environments corresponded to the daily, weekly, semesterly, and yearly cycles of the classroom. Over the course of a semester Levin, et al., found that communication activity would slowly build to a peak, and then fall away completely when everyone left for Christmas vacation. While this patterns seems obvious upon reflection, the point is made that this "calendar effect" needs to be of critical concern to designers from environments other than K-12 who may not take details of the academic calendar into account.

Levin, et al. (1992; 1989) only considered so called "calendar effects," and did not study additional effects of the task environment. A richer perspective on the activity cycle as it relates to tool use can be determined with a focus on the nature of the tasks that comprise project cycles, and how collaborative systems can in turn be instrumental to the successful completion of those tasks. Furthermore, Levin and his colleagues studied classrooms where e-mail was the only tool available, and only used for special purposes. The classrooms in this study have a rich "ecology" of CMC tools, and students and teachers may use them for a variety of tasks, both work-related and social in nature.

In classrooms that participated in this study, activity cycles correspond to the time it takes to initiate, pursue, and complete science projects. Project cycles can be very short—just a day or two—or very long, lasting an entire semester. Common elements of all project cycles are a teacher introduction, a period when students seek information and data sources, a period when students begin to shape a final product, and a presentation and evaluation phase at the end. This cycle is similar to a model of research collaboration in white-collar environments that was described by Kraut, Galegher, and Egido (1987). In their model, Kraut, et al., divide projects into three major phases: initiation, execution, and public presentation. It is important to understand the different phases of the activity cycle in the classroom because in each phase there are unique demands placed upon CMC tools that are characteristic to the work being pursued. In the current study, one would expect to see patterns in CMC tool use that correspond to particular stages of

the activity cycle. It was predicted that there would be an initial peak of CMC tool use early in each project cycle, followed by a gradual decrease in use until each project concluded.

Methods

This research was conducted as part of the Learning Through Collaborative Visualization (CoVis) Project (Pea, 1993) during the 1994-95 academic year. It should be noted that at that point in time, the majority of students had never before used e-mail, and the World-Wide Web was still in its infancy, unknown in most classrooms. Two high schools were involved in this project, both located in the suburbs of Chicago, Illinois. The subjects in this study were 280 students and six high school teachers, three at each school. Five of these teachers were in their third year of participation in the CoVis Project, and one teacher was in his first year of participation with CoVis.

Automated Logs of CMC Tool Use

CMC tool use is the primary dependent measure in this work. Because these tools are computer-based, it was relatively easy to gather data on their use. Each of the three CMC tools in this study—electronic mail, Usenet news groups, and the Collaboratory Notebook— generated a log of its use in CoVis classrooms. The basic measure of e-mail use was messages sent. The basic measure of news use was messages posted. The basic measure of Notebook use was pages created. These logs were then analyzed to generate usage statistics for individual subjects. "Amount of use" in this study refers to the number of messages or pages created by students using each of the four CMC tools. Messages received was not measured, because receiving is a passive act, and without close observation (deemed too costly for the constraints of this study), it is impossible to tell which messages are actually read and which are not.

At several points in the reporting of this data, CMC tool use is reported as an aggregate of e-mail messages, Usenet news articles, and Collaboratory Notebook pages. While the authors recognize that message "units" in each of these tools are not equivalent, this aggregation allows for a quick overview of student activity. When looking at cases of individual activity within classrooms, use is considered one CMC tool at a time.

Teacher Interviews and Classroom Observations

One-on-one interviews were conducted with each of the teachers at the conclusion of the school year, designed as a retrospective conversation about the activities in their classrooms and they way those activities employed CMC tools. Each interview was supported by a series of graphs that depicted use of individual CMC tools week-by-week by classroom. Teachers were prompted to discuss the activities they used to introduce each communication tool. Next, the conversation turned to the broad project or activity cycles of the classroom, with particular focus on how CMC tools were used as part of these activities. At each step, teachers were asked to consult the graph of CMC tool use and attempt to explain the "peaks" and "valleys" of the data. The goal of the interview was to determine if there teachers can reasonably account for the flow of CMC tool use in their classrooms to their planned activities. Additionally, each of the teachers was asked to rate their own skill and comfort level with each of the CMC tools. This information was gathered to evaluate whether teachers' attitudes influenced student tool use, in the way that Schmitz & Fulk (1991) found that supervisors' attitudes influenced employees' tool use. In addition to this interview data, classroom observations were conducted almost daily by the author and other members of the CoVis research team. These observations resulted in a general familiarity with the activities of each classroom, allowing for triangulation with other data sources.

	Mail Messages Sent	News Articles Posted	Notebook Pages Created
Mean	38.9	2.7	7.6
Range	0-327	0-71	0-41

Table 1. CMC tool use means and ranges by CoVis students during 1994-95

Results and Discussion

During the 1994-95 academic year, CMC tools were widely used by students in CoVis classrooms. Table 1 reports the means and ranges of each tool's use by students. The use of these tools was not evenly distributed among students, but rather was skewed positive (with the exception of Notebook use, which was normally distributed). The number of students who created very few (or no) messages with these CMC tools was much larger than the number of students who created a lot of messages. Also, e-mail was used far more than any other tool. Painted in these broad strokes, at least, student use of CMC tools is similar to the way these tools are employed in white-collar settings, and also similar to reports of

CMC tool use in the home (Kraut, Scherlis, Mukhopadhyay, Manning & Kiesler, 1996).

Confirmation of the Calendar Effect

The data in this study confirms Levin, et al.'s (1992; 1989) findings that a calendar effect exists with respect to CMC tool use in school settings. Patterns of CMC tool use in CoVis classrooms appear to be related to the cycles of academic quarters. Figure 1 represents the flow of message creation for all CMC tools (as an aggregate) during the entire school year.

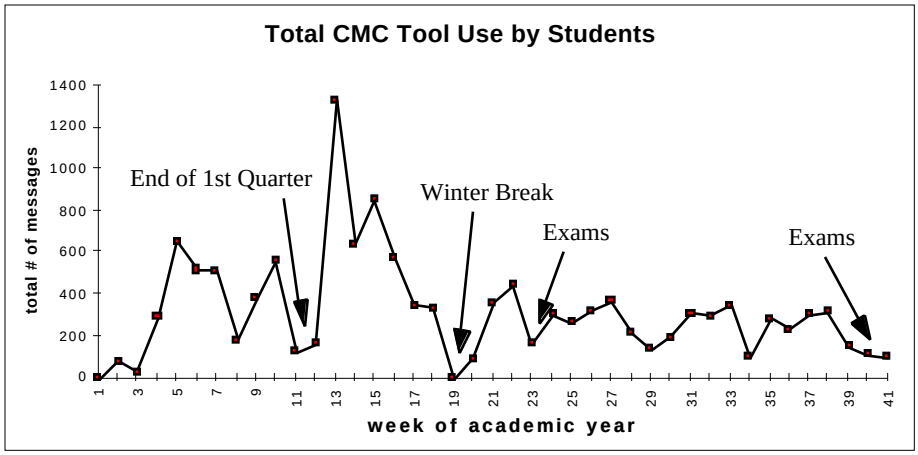

Figure 1. Overall student CMC tool use by week.

The first quarter, which lasted from weeks 1 to 11/12 (the academic calendars at the two schools were not perfectly synchronized), saw a steady increase in CMC tool use as all students were introduced to the tools and began practicing with them. This steady growth declines again to a low point at the end of the quarter. The second quarter, from weeks 11/12 to 22/23, saw overall higher tool use at its start, interrupted by the Winter Holidays in week 19, and then another low point at the end of the quarter. Overall use is lower during the second two quarters than in the first two quarters, but there are again "humps" of CMC tool use that match the third (weeks 23/24-31/32) and fourth (weeks 32/33-41) quarters (the fourth quarter at each school actually begins with the week of Spring Break, also a low point in use).

Another pattern that is related to semester-long cycles is the decline of tool use in weeks preceding exams, as schools have shorter hours and students are putting in more time to review the work in all of their classes. Other dips in the number of messages sent in particular weeks are attributable to special schedules that schools have from time to time, to accommodate teacher in-service, parent-teacher conferences, and all-school events. Understanding these patterns is key to the success of collaborative projects in schools as mentors, and others who live outside of the school calendar, need to shape their response expectations appropriately.

Tales from the Classroom

There are aspects of classroom activity, however, that are related to patterns of CMC tool use and extend beyond simple calendar effects. Lienhardt, Weidman, and Hammond (1987) argue that in order to understand what students do, it is necessary to identify the activity structures that comprise "goal directed segments of teacher and student behavior that involve teachers and students in particular actions" (p. 135). It is important to point out that, although most activity reported in this study is teacher directed, student use of CMC tools is not (except where noted below). Rather, the use of CMC tools is an emergent property of the activities.

Three examples have been selected from the data to represent the relationship between CMC tool use, activities, and teachers' attitudes. The first example illustrates a pattern of CMC tool use where the tool is instrumental to the completion of project tasks. The second example illustrates the converse—what happens when the tool is clearly *not* instrumental. The final example illustrates how a teacher's attitude towards a particular tool can influence its use by students. The teachers' self-reported confidence level with the tools is also reported with each example. The data indicates that in cases where teachers report that they are "expert" or "very skilled" with CMC tools, their students readily use them. In cases where teachers report that they are only "moderately skilled" with a CMC tool (this was the lowest rating chosen by any of the teachers), their students do not use the tool very much.

Instrumental Use of Usenet News

Mr. Wolf (all names used in this paper are pseudonyms) taught three sections of Earth Science (*n*=65 students). He introduced Usenet news with a

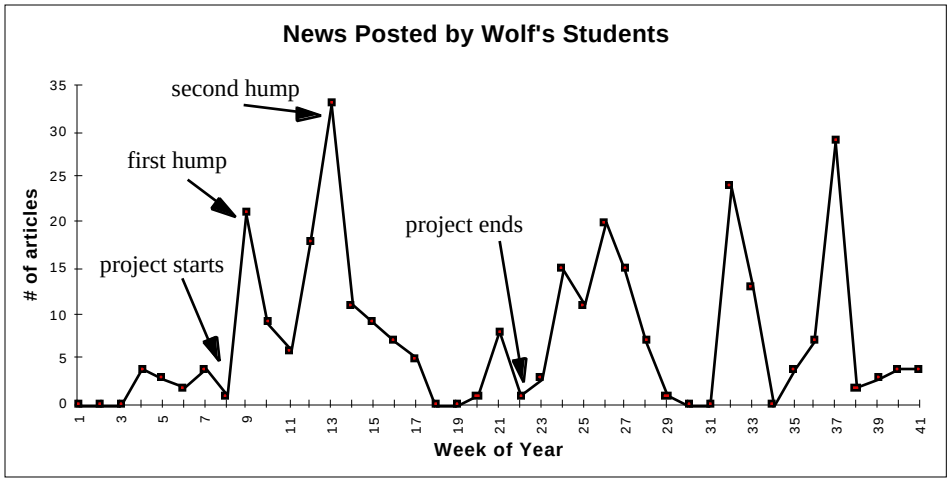

Figure 2. News articles posted by Mr. Wolf's students.

short project, in which students were instructed to read all the threads with more than five articles in them in relevant science news groups (e.g., sci.environment, sci.geology) and send the teacher an e-mail message with the name of the thread and a list of geographic locations where the individual articles came from. During this first news activity, students were discouraged from actually posting any messages. This reading activity took place between weeks 4 and 8 (see Figure 2), and the messages that are posted during this time are a combination of "accidents" and students making postings to some of the social news groups (e.g., k12.chat.senior).

Regarding the use of CMC tools in general, and the relationship of this use to project cycles, Mr. Wolf's classes had three major project cycles during the school year. Selection of topics for each cycle was up to the students. The first cycle ran from week 9 to week 19, the second cycle from week 20 to week 30, and the third cycle ran from week 32 until week 41 at the end of the school year. For news, a "two-humped" pattern of use appears within each of the project cycles (see Figure 2). The first peak in news use within each project cycle is attributed to the students Mr. Wolf calls "the self-starters." A few weeks into each project cycle, when many students ran into dead-ends in their search for data or other project information, Mr. Wolf would often recommend that they go back to the Usenet news groups in search of help, thus initiating the secondary peak in news postings during each of the project cycles. News was thus instrumental for these students in accomplishing the short-term tasks of their project work. Mr. Wolf rated himself "an expert" with news.

Non-Instrumental Use of the Collaboratory Notebook

Mr. Miller taught two sections of Earth Science (*n*=79), and introduced the Collaboratory Notebook to his students in week 12 (see Figure 3). Mr. Miller's description of student Notebook use after that date is an initial flurry of page creation to set up the basic structure of the notebooks, followed by students

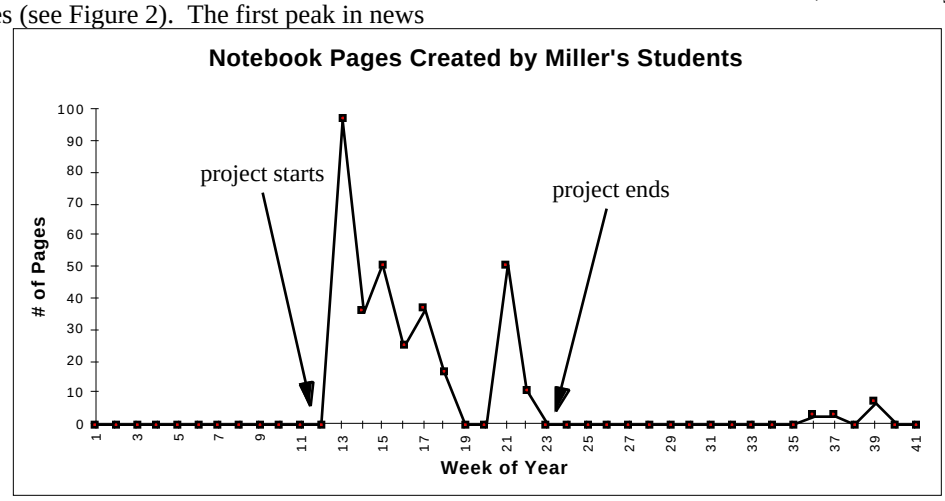

Figure 3. Notebook pages created by Mr. Miller's students.

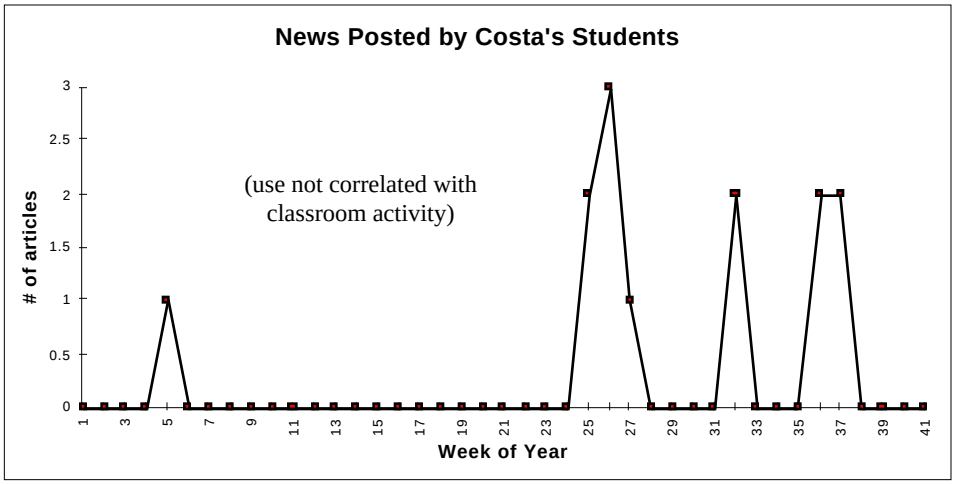

Figure 4. News articles posted by Ms. Costa's students.

going back to fill in the pages with information, creating new pages less frequently. This is borne out by the use patterns shown in Figure 3 (note the last minute burst of new page creation right before the end of this project in week 20).

Mr. Miller's classes engaged in two more project cycles during the second semester. The third project, from weeks 25 to 33, was on earthquakes, and focused on the creation of a video tape. Mr. Miller did not encourage use of the Notebook for this project, and it was not used. The final quarter (weeks 35-41) was spent pursuing topics of the students' choosing. One project group chose to use the Notebook, but it did not play a central role in their project, as evidenced by the relatively low number of pages created during this time. In Mr. Miller's classroom, use of the Collaboratory Notebook occurs for the most part when the teacher directs it to occur. Students by and large did not use the tool in support of general project work. The major implication is that they found other ways to meet the goals of their project work, and the Notebook did not serve an instrumental role outside of pleasing their teacher. Mr. Miller rated himself as "moderately skilled" with the Collaboratory Notebook.

Teacher Apprehension and Usenet News

Ms. Costa taught two sections of regular Earth Science (*n*=43). She introduced news to her classes in week 4, and the introduction to news consisted of having her students summarize a news group discussion and e-mail the summary to her. Ms. Costa rated herself as "moderately skilled" with news. Ms. Costa's opinion of news was heavily influenced by the experiences of another teacher, Ms. Steele. A student in Ms. Steele's class had posted a rude message to a science news group. The student claimed that it was an accident; he meant to send it as e-mail to a friend. Ms. Steele was very disturbed by this. She considered news essential to her students' work, and did not want the people in this news group to develop negative feelings towards her students.

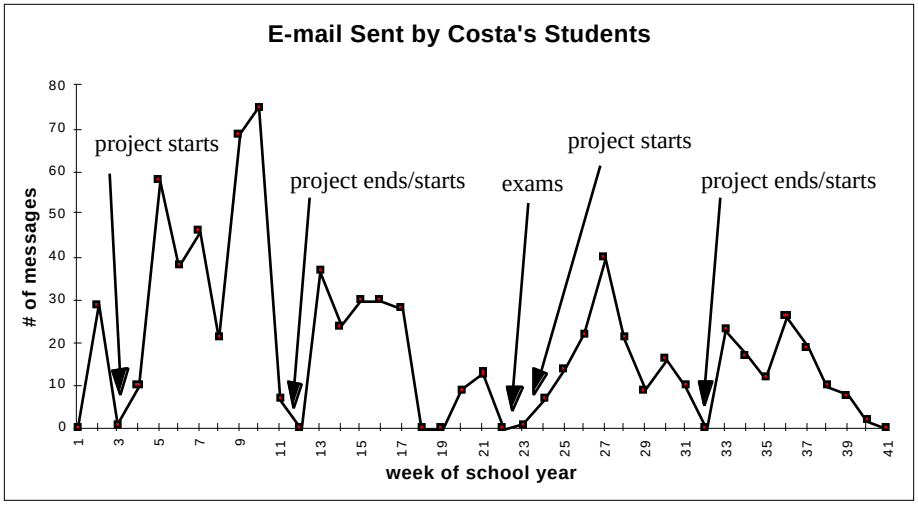

Figure 5. E-mail messages sent by Ms. Costa's students.

Ms. Costa did not want to have a similar experience in her classroom, so as part of her introductory activities for news, she lectured her students and warned them very sternly against posting inappropriate messages. The use of news by Ms. Costa's students is extremely low. Week 26 was the peak for news posting, but only 3 messages were posted by all of Ms. Costa's students (see Figure 4). Ms. Costa explains this lack of postings as the result of her "scaring them out of using news," after the problems that Ms. Steele experienced. When asked to explain the few postings that her students did make, she said that she believed most to be "accidental."

By contrast, consider the use of e-mail in Ms. Costa's classroom (see Figure 5). Ms. Costa's students use e-mail considerably less than other teachers' students (ranked consistently lowest), but they do use e-mail to support project work in patterns consistent with those found in other classrooms. Ms. Costa's classroom presents a clear example of teacher attitudes towards a CMC tool impacting its use by students. Ms. Costa's apprehension about news was clearly communicated to her students at the start of the year, and as a result they post to news less frequently than students in any other class.

Design Implications Of Activity And Calendar Effects

The school calendar creates a work flow that is unique to the K-12 environment. Patterns of student CMC tool use respond to the regular rituals of the school calendar by dropping off to relatively low levels at times when students are engaged in non-computer activities like preparing for exams, and also (predictably) during vacations. A design issue relating to calendar effects was pointed out by Levin, et al. (1992). In their paper on calendar effects, they argued that knowledge of the school calendar needs to be communicated to anybody who intends to collaborate or communicate with school students. Levin, et al., refer to this as "shaping response expectations." Mentors, for example, could easily be frustrated by a seemingly non-responsive student. In fact, what could be happening is that the student has been out of regular classes for a week during exams or perhaps Spring break. For schools that are trying to collaborate, it is also important to share information about each others' schedule. Schools located in different hemispheres, for example, have very different academic years. In some places, such as Japan, many schools operate year round, and might be surprised to find out that a fruitful collaboration with an American schools needs to end in June.

Another design implication of this recommendation is that school CMC systems might be configured to allow students to access tools like e–mail, news, and the Collaboratory Notebook from home. If calendar effects are actually an indication of when students do and do not have access to CMC tools, then these limitations might be mitigated or even disappear completely if students had access to CMC tools from their homes. Students would continue to use CMC tools after school hours, during times when they did not regularly have class, and during vacations. This would greatly alter the response expectations that people would need to hold for collaborative activity with school students.

Classroom activity is the second force that drives patterns of student CMC tool use. These patterns exist at both a macro- and a micro-level in each teachers' classroom. At the macro-level, student CMC tool use increases and decreases with the start and end of discrete activities, respectively. At a micro-level, there are identifiable patterns of CMC tool use that exist *within* the bounds of each classroom activity. At both of these levels, student CMC tool use is a response to what Doyle (1979) referred to as the "task variables." Doyle argued that the way teachers structure tasks is the strongest driver of student behaviors, such as CMC tool use.

Macro-level effects describe tool use patterns that are related to entire activities. These activities include various kinds of tool introduction exercises, and then between three and six projects that lasted for the rest of the academic year (depending on the individual teacher). At this level of analysis, there is clearly an interaction between the effect of teacher-designed activities and the calendar effects discussed earlier. For example, in many cases project cycles correspond to the beginning and end of the academic quarter. The same decline in CMC tool use that could be explained by an approaching exam or grading period is equally well described by the approaching end of work on a particular project. This dual-explanation does not exist, however, for shorter-duration activities, such as the introductory activities for each CMC tool. In these cases, the use of the CMC tools corresponds almost exactly with the duration of the activity.

The micro-level patterns of CMC tool use that exist within each project or activity are in general more interesting than the macro-level cycles. At this level of analysis, the instrumental nature of the CMC tools for accomplishing student work emerges. There is a rapid rise in CMC tool use at the start of each project cycle. Parameters of these projects usually include the need for data or other information to be found on the Internet, resulting in immediate student needs to use news or e-mail. This phase of project work has students actively involved in "information gathering." In the case of the Collaboratory Notebook, teachers reported that students would frequently begin work by creating a number of pages which would be filled in and elaborated on at a later date. This explains the initial rise in the number of Notebook pages created at the beginning of project cycles. After students have finished gathering

information for their projects, there is a long period of work where the goals set out during the initiation phase are worked on. This is the phase that Kraut, et al. (1987) referred to as "execution," and is accompanied by the steady-state pattern of CMC tool use. Not infrequently, students in this phase of project work discover that they do not have sufficient material with which to complete their project goals. This situation is met with a second round of CMC tool use where students attempt to supplement their initial work. In Mr. Wolf's classroom, for example, he reports that when students in this phase of work become "stuck," he would frequently suggest that they return to Usenet news in order to find more sources of information. Towards the end of projects there is a final small increase in CMC tool use, which can be explained in a fashion similar to that of the mid-project increase. Students are looking for more information at the last minute to supplement their project work.

Conclusion

The science classrooms that participated in this study provide a valuable service as testbed environments for high-end communications technologies. These CMC tools, which are now commonplace in white collar and industrial settings, have begun a rapid expansion into classrooms. The most important implication of this study is the caution that this expansion process be viewed as more than just technology transfer. Instead, the marriage of classroom learning and CMC tools needs to be treated as an opportunity to redesign aspects of both the tools and the activities of the classroom. In particular, this study suggests that if the goal is to sustain CMC tool use in classrooms, a focal area of concern should be the design of activities.

Design issues for collaborative tools and systems are, by nature, rooted in particular contexts. In order to understand what has been called the "communication needs" (Hollan & Stornetta, 1992) of participants in particular settings, one must engage in the study of the tasks and roles of those participants. The primary goal of this work is to determine if there are recognizable patterns that exist in the CMC tool use behaviors of these students, and if so, how those patterns can best be characterized. Using these emergent patterns to augment our understanding of the design space for collaborative and computer-mediated communication tools in high school contexts allows us to increase the usefulness of those tools to both students and teachers in the future.

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References

Doyle, W. (1979). Classroom tasks and students' abilities. In P. L. Peterson & H. H. Walberg (Eds.), *Research on teaching: Concepts, findings, and implications* (pp. 183-209). Berkeley, CA: McCutcheon.

Fishman, B. (1996). *High-end high school communication: Tool use practices of students in a networked environment.* Unpublished doctoral dissertation, Northwestern University, Evanston, IL.

Hollan, J., & Stornetta, S. (1992). Beyond being there. In P. Bauersfeld, J. Bennett, & G. Lynch (Eds.), *ACM Conference on Human Factors in Computing Systems* (pp. 119-125). Reading, MA: Addison Wesley.

Kraut, R., Scherlis, W., Mukhopadhyay, T., Manning, J., & Kiesler, S. (1996, December). The HomeNet field trial of residential Internet services. *Communications of the ACM, 39*, 55-63.

Kraut, R. E., Galegher, J., & Egido, C. (1987). Relationships and tasks in scientific research collaboration. *Human-Computer Interaction, 3*, 31-58.

Lienhardt, G., Weidman, C., & Hammond, K. M. (1987). Introduction and integration of classroom routines by expert teachers. *Curriculum Inquiry, 17*(2), 135-176.

Levin, J., & Cohen, M. (1985). The world as an international science laboratory: Electronic networks for science instruction and problem solving. *Journal of Computers in Mathematics and Science Teaching, 4*(4), 33-35.

Levin, J., Waugh, M., Chung, H. K., & Miyake, N. (1992). Activity cycles in educational electronic networks. *Interactive Learning Environments, 2*(1), 3-13.

Levin, J. A., Kim, H., & Riel, M. M. (1989). Analyzing instructional interactions on electronic message networks. In L. M. Harasim (Ed.), *Online education: Perspectives on a new environment* (pp. 185-213). New York: Praeger.

O'Neill, K., Edelson, D., Gomez, M., & D'Amico, L. (1995). Learning to weave collaborative hypermedia into classroom practice. In J. Schnase & E. Cunnius (Eds.), *Computer Support for Collaborative Learning* (pp. 255-258). Mahwah, NJ: Erlbaum.

Pea, R. D. (1993, May). Distributed multimedia learning environments: The Collaborative Visualization Project. *Communications of the ACM, 36*, 60-63.

Riel, M. (1989). *Telecommunications: A tool for reconnecting kids with society*. Paper presented at the meeting of the International Symposium on Telecommunication in Education, Jerusalem, Israel.

Schmitz, J., & Fulk, J. (1991). Organizational colleagues, media richness, and electronic mail: A test of the social influence model of technology use. *Communication Research, 18*(4), 487-523.

Schwab, R. G., Hart-Landsberg, S., Reder, S., & Abel, M. (1992). Collaboration and constraint: Middle school teaching teams. In J. Turner & R. Kraut (Eds.), *Computer Supported Collaborative Work* (pp. 241-248). Toronto, CA: ACM Press.

Authors' Addresses

Barry J. Fishman, The University of Michigan, School of Education, 610 E. University, Ann Arbor, MI 48105. Ph: 734-647-9572.
E-mail: fishman@umich.edu

Louis M. Gomez, Northwestern University, School of Education and Social Policy, 2115 N. Campus Drive, Evanston, IL 60208. Ph: 847-467-2824.
E-mail: l-gomez@nwu.edu