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Chat Rooms as "Virtual Hangouts" for Rural Elementary Students

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This article is a description of how 24 rural, 5th-grade students with home Internet access used an Internet chat application after school and how this usage changed during a one-year period. Study results have implications for curriculum design (e.g., how teachers can use chat to stimulate collaborative learning after school), student-teacher interactions (e.g., how can teachers maintain their authority in this new environment), and research (e.g., how does gender affect student usage of chat).

Internet technologies offer numerous opportunities to foster student involvement in the classroom community during after-school hours. These

technologies can be particularly helpful in rural areas where students are often separated by many miles. Distance can make it difficult, if not impossible, for rural students to interact after school or to complete extracurricular collaborative activities. Educators wishing to encourage after-school interaction have a variety of network communication tools available to them. One such communication tool, specifically text-based chat, is the focus of this article.

Chat allows geographically isolated students to sustain synchronous dialogues with distant peers and provides a flexible medium for group construction of knowledge. Chat can be used to enhance home learning activities by facilitating collaborative learning, improving out-of-class communication, and providing a nonintimidating forum for students to voice classroom concerns. This article presents a preliminary investigation of how rural elementary students with ubiquitous access to network technology used a text-based chat facility after school. The information presented in this article comes from a number of sources including computer-generated chat usage statistics, transcripts of chat sessions, teacher observations, and student interviews.

BACKGROUND AND CONTEXT FOR THIS STUDY

The PCs for Families Project (PCF) has been investigating Internet technologies, including text-based chat, to learn how learning outside of the classroom might be enhanced. The PCF project is a three year program sponsored by the Department of Education in conjunction with a rural elementary school (http://pixel.cs.vt.edu/edu/fis). A networked computer is sent home with each participating child and teacher, and all program participants, including parents, are provided free Internet access. Students selected for the program spend 5^{th} grade in a specially designed networked classroom, then continue on to a conventional 6^{th}-grade classroom but keep their home network technology. A more detailed discussion of the project can be found in Ehrich, McCreary, Reaux, Rowland, and Ramsey (1998).

The PCF project used a variety of commercial and project-developed software packages in the classroom and home. The chat facility that is the focus of this article is an example of project-developed software and was introduced to the students in an after school technology training session. The interface for the chat application is very simple and easier for children to use than most commercial chat packages. It has built-in security measures which limit use to project participants, thereby ensuring the privacy of the students. It also has the advantage of built-in logging, which allows researchers to study chat usage patterns in great detail.

While in the network classroom, a number of PCF students discovered that chat was a novel and fun way to hold group study sessions on test material. Using this facility, the students practiced writing and expressing themselves. At the students' invitation, a teacher joined in, which gave the children the opportunity to discuss issues beyond the normal academic ones discussed in the classroom. This allowed participating teachers to obtain insights into class dynamics that would not have been otherwise revealed. This article presents a preliminary investigation of how PCF students used the project chat application after school. Specifically, this research explores home chat usage for the second cohort of students participating in the project beginning in the last half of 5th grade and ending in the first half of 6th grade.

Patterns and Predictors of Technology Usage

To study whether students' use of the chat application would change over time, research analyses included a time variable. Previous studies of computer use indicated that student computer usage changes with time. For instance in a study with palmtop computers, Robertson, Calder, Fung, Jones, and O'Shea (1997) found that heaviest computer use was initially when students were trying to see how the computers worked, with use dropping off 30 to 40 % over the course of five months. Similar patterns were seen in preliminary analyses of PCF World Wide Web (WWW or Web) and e-mail usage data (Ehrich & McCreary, 1999). Preliminary analysis of usage patterns of PCF participants for other network technologies indicated that gender also affected technology use (Ehrich & McCreary, 1999). Other researchers have reported that girls typically have less interest in computer games and greater interest in using computers to communicate and create, whereas with boys this pattern is reversed (Means & Olson, 1995; Mohamedali, Messer, & Fletcher, 1987; Ross, Smith, Morrison, Ericson, & Kitabchi, 1989).

As part of this research, data on student individual differences were also collected. Earlier research found that individual differences, particularly cognitive style, were likely to be related to student usage of technology. Studies with adults had indicated learning style was significant factor in computer usage (e.g., Enochs, Handley, & Wollenberg, 1986), with some studies suggesting that highly visual and abstract adults use e-mail with greater ease (e.g., Sein & Bostrom, 1989). Personality type had also been found to be significant, with "perceiving" individuals favoring use of "rich media" such as e-mail and "judging" individuals favoring more traditional

media (Schmitz & Fulk, 1991; Trevino, Lengel, Bodensteiner, Gerloff, & Muir, 1990).

METHOD AND RESULTS

In the year the chat facility was introduced, 24 5th-grade students (8 girls and 16 boys) participated in the PCF program, with students randomly selected from the larger school population. All students had attended the rural elementary school since at least the 3rd grade. The chat application was introduced to the students and teaching staff in the middle of the school year near the end of January. By this time, both students and teachers were long-time Internet users and were adept at logging onto the Internet from home.

Data Collection

The chat usage data analyzed here came from the PCF proxy server logs. The following chat metrics were developed from the logs: (a) the number of utterances, that is, lines input to the chat application, (b) the number of conversations, that is, chat sessions involving more than one user with no more than two minutes of idle time between individual lines, (c) the number of non-connections, i.e., sessions involving only one user, (d) chat social networks for students and teachers, and (e) classification of chat communication as either social, school-related, or disruptive (e.g., nonsense entries, blank lines). Due to the discrete and nonnormal nature of the resulting data sets, nonparametric techniques were used for analysis.

Previous literature and preliminary analysis of other project network data indicated that user individual differences were likely to be related to actual chat usage. The following variables were used to explore the impact of individual differences on chat usage: (a) gender (male versus female), (b) 3rd-grade Iowa Test of Basic Skills (ITBS) scores, (c) learning style scores (verbal, visual, kinesthetic), and (d) Murphy-Meisgeier personality type indicator (MMPI) scores (Thinking-Feeling, Judging-Perceiving, Extroversion-Introversion, Sensing-Intuition).

Nature of Chat Usage

Of the 24 students and two teachers who had access to the PCF chat facility, 12 students and two teachers logged into the chat room. During the period under consideration, a total of 2,910 lines were written by participants. Usage essentially ceased after the students left the 5th-grade, network classroom. Among the participants, chat usage differed substantially as shown in Figure 1.

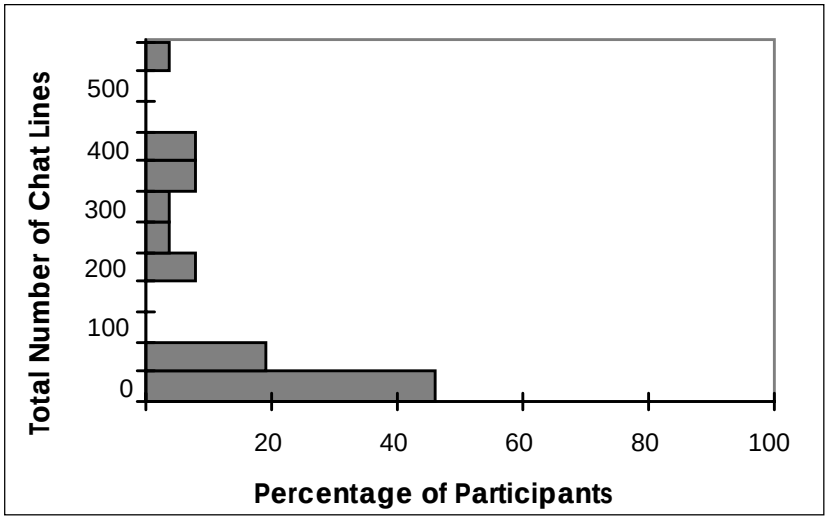

Figure 1. Distribution of chat lines for participants during the first year of use

While the average student logged into the chat room approximately 1.86 times a month during 5th grade, some of the participants logged onto the chat room several times a week and entered over 500 chat lines. Of the 179 logins to the chat facility during 5th grade, 52 student logins and six teacher logins resulted in nonconnections, that is instances of the user never interacting with other individuals while in the chat room, with the remaining logins resulting in a total of 42 conversations. As shown in Figure 2, the vast majority of chat rooms conversations involved only two individuals.

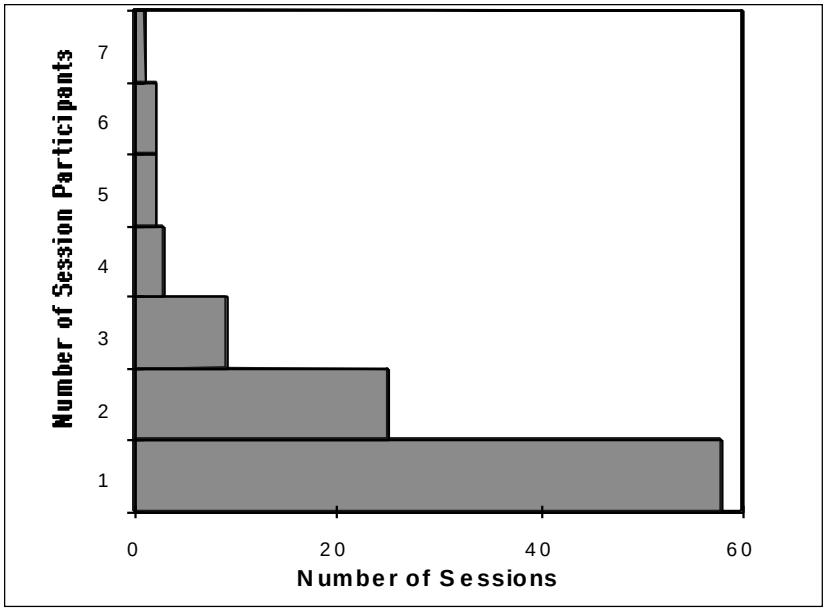

Figure 2. Group sizes during chat sessions

Individual lines from chat transcripts were classified as either (a) disruptive, for example, blank lines or random strings of characters, (b) social, or (c) school related. In all, 471 lines were classified as disruptive, 797 lines related to classwork, and 1642 lines were social in nature. Friedman's Two-way Analysis of Variance by Ranks found very strong evidence that usage differed significantly by category ($p < .0001$, adjusted for ties). Wilcoxon Signed Ranks post-hoc tests on the data found strong evidence that chat was used more often for social purposes than for either school or disruptive purposes ($p < .006$, adjusted for ties), but only mild evidence that school-related use was more frequent than disruptive use ($p < .078$, adjusted for ties). There was weak indication that males used chat for disruptive purposes more often than females ($p < .29$, adjusted for ties). School use related to the following subjects: writing (546 lines), science (133 lines), and history (90 lines). Chat writing activities were primarily brainstorming, while science and history usage related mainly to quizzing in preparation for tests.

Patterns of Chat Usage

Approximately two weeks after the chat facility was first introduced in an after school technology training class, students began to adopt it. In order to assess the impact of the length of availability on chat usage, the year was divided into one month periods. The main dependent measure used for time analyses was the number of lines input to chat. As seen in Figure 3, merely having access to the technology was not sufficient to encourage use, even when students had a strong history of previous use, once students left the network technology classroom. In fact, usage dropped off sharply a month before 5th grade ended as outdoor and end-of-school activities reduced time spent on the computer. Friedman's Two-way Analysis of Variance by Ranks found significant evidence that usage varied by month (p <.045, adjusted for ties). Again, Wilcoxon Signed Rank Tests were used for posthoc analysis. The posthoc tests found strong evidence that usage in February, March, and April was greater than usage in the following months (p < .01). No other significant differences were found.

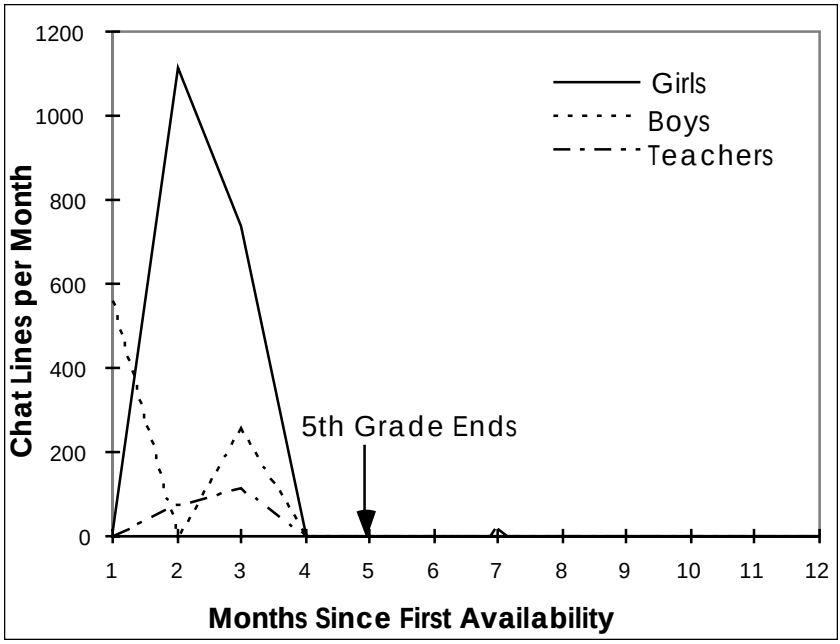

Figure 3. Total number of chat lines by demographic group

In keeping with earlier studies which found girls made greater use of technology for communication purposes than boys (e.g., Means & Olson, 1995), the Mann-Whitney-Wilcoxon Test found strong evidence that girls made substantially greater use of the chat facility than boys ($p < .004$, adjusted for ties). In fact, boys used the chat facility significantly more than the girls only in the first month ($p < .05$), when usage was still primarily exploratory in nature. As seen in Figure 4, the girls used the chat room primarily to connect with other girls or female staff members. Spearman's Rho procedure found some evidence that the number of lines input each week by girls was positively related to inputs by female teachers ($p < .15$). No correlation between girl-boy usage or boy-teacher usage was found.

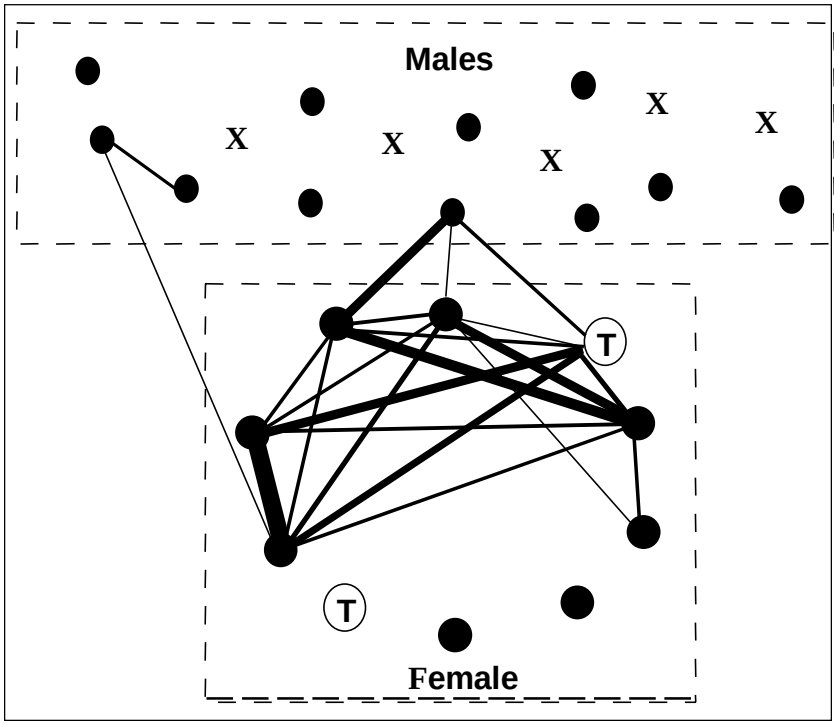

Figure 4. Chat connections among class members. Dots represent class members, Ts represent classroom teaching staff, and Xs indicate individuals who logged onto chat but never managed to connect with other class members. Lines denote chat connections between individuals, with line width denoting frequency.

Girls were more persistent than boys when it came to chat use. Of the eight boys who logged onto chat, five never connected with other participants. When boys found no one in the chat room, they would just log off; however, girls would wait for others to arrive and were often proactive in contacting other students by way of the phone or e-mail to make chat room appointments. Girls also often took time during a chat session to schedule their next session. Of the 134 lines related to scheduling in the chat transcripts, only five can be attributed to the boys in the class.

Predictors of Chat Usage

Rank General Linear Model regression was used to identify the characteristics of classroom members that predicted differences in the total number of chat lines between participants. The analysis reported here is preliminary and does not include differential effects of time, other network usage (e.g., e-mail), interactions among variables, or higher-order predictors. Best subsets of predictors were developed using the maximum R^2 criterion, where R^2 is the proportion of variance accounted for by the predictors. That is, the best one predictor regression model was selected based on the largest R^2 value, then the next best two predictor model was developed, and the process continued until all predictors were used. The model with the highest R^2 value was then selected.

The initial set of predictor variables was developed based upon previous literature and preliminary analysis of PCF network data; this set included (a) gender [male=1, female=2], (b) 3rd-grade ITBS scores, (c) learning style survey scores, and (d) MMPI scores. The best resulting subset of predictor variables was comprised of student gender (GEND), MMPI judging-perceiving score (JP), and ITBS vocabulary (VOCAB), comprehension (COMP), and language (LANG) scores. The corresponding first order model is shown in Equation 1 :

TC = 324.0 + 176.0 GEND - 8.44 JP + 4.04 VOCAB - 4.40 COMP + 2.90 LANG (Eq. 1)

where TC is total number of chat lines input for the year. The variables in this model accounted for 52.9% percent of the variance in total chat lines. Summary information for this model can be found in Table 1.

Table 1
Test of Significance of Empirical Model Parameters for Model

Variable	b	Standard Deviation Estimate	*t* for H_0: b=0	*p*	R^2
GEND	176.00	256.50	1.26	.22	.24
JP	-8.44	2.90	-2.91	.01	.07
VOCAB	4.04	1.57	2.57	.02	.09
COMP	4.440	1.72	-2.56	.02	.08
LANG	2.90	1.64	1.77	.09	.04

Gender was the strongest predictor of chat usage with girls using chat more than boys. Not surprisingly, given the highly verbal nature of chat interchanges, the ITBS vocabulary score was the second strongest predictor of chat usage. Similarly, students with higher ITBS language scores used the chat facility more than those with lower scores. Interestingly, chat usage decreased as the ITBS reading comprehension score increased. Possibly, this variable acted as a suppressor variable, that is, although the reading comprehension variable was not highly correlated with chat usage, it may have suppressed irrelevant variation in the two other ITBS scores and led to an overall improvement in prediction. One potential explanation is that the comprehension variable discounted the scores of those who did well on the language and vocabulary portions of the tests simply because of their reading comprehension rather than verbal abilities linked to higher chat usage.

Unlike earlier studies with adults, which found use of network technology was higher for perceiving individuals (e.g., Schmitz & Fulk, 1991), this study found that chat usage was higher for judging students (as indicated by lower JP scores). This may be an artifact of the lack of continuity of student JP scores. Although, score values were fairly evenly distributed in the [70, 88] interval, a 16-point gap existed between that interval and the next lowest score. Only two students scored below 70 on the MMPI JP scale and each student made heavy use of the chat facility. More data could potentially eliminate the gap in MMPI scores and help determine if the large number of accesses made by students at the low end of the scale were outliers or indicators of a trend.

DISCUSSION

Student communication using chat was interactive, conversational, personal, and easy. Other than network lapses, students experienced few technical problems when using chat. Project 5^{th}-graders took advantage of the

opportunities offered by chat to socialize, study together, and communicate with teachers during evening hours. Students used chat to quiz each other for tests, write a collaborative fairy tale, and plan presentations. One group of students used the chat room to coordinate a cooperative learning project involving not only themselves, but others in the class as well.

Chat as a Medium for Communication

Students took advantage of what they perceived to be a less intimidating environment to share concerns and ideas. Students commented freely on classroom activities and shared their feelings about their learning environment and the impact of technology. Frequently, students invited project teachers to participate and would often raise issues that they were uncomfortable about addressing face-to-face. An example of one such interchange is shown here.

> Student1: Why does so many people play games during class. I don't because have a computer at home!
>
> Teacher: That's a good question, Student 1. Sometimes it's frustrating isn't it, because it slows us down sometimes. What do you think?
>
> Student1: I don't know but it disturbs me.
>
> Teacher: Why does it disturb you?
>
> Student1: Because when I turn off the monitor Student2 yellls at me for it.
>
> Student1: Really we have the worst troubles because we are girls and the boys think they are tough.

One female student in particular benefited from the opportunities offered by chat. Although very social with her peers at school, she rarely made connections with them after school. Due in large part to a challenging home life, she was usually unable to attend group gatherings hosted by other students, nor was she able to invite peers into her home. Her extracurricular social interactions were limited to infrequent invitations to no more than one student, and she could not join academic groups or athletic teams. For this student, network technology was exactly the tool that she needed to

stay involved with her peers. She used the chat room frequently, played a major role in project planning sessions for an extracurricular project, and often took the lead in scheduling after school chat sessions.

By combining social and academic activities with a facility that requires students to express their ideas and their conversations in writing, a chat room has the potential to become a powerful tool for fostering academic growth in students because students do not perceive their sessions as work to be done. The following excerpt from a chat transcript illustrates that students did a lot of writing when using chat, and enjoyed it:

Student1: Boy have we been writeing a lot

Student2: I'M HAVING FUN

Student3: ME TOO

Student1: ME TO!!!!

Student4: me third

CHAT AS MEDIUM FOR TEACHING

Possible uses for chat facilities are not limited to after-school social interaction and study groups. Chat facilities offer a wide variety of opportunities for academic collaboration among students in the classroom and at home. They allow students to engage in discourse with professionals in distant locations or with students in other classrooms. Chat transcripts can be a valuable assessment tool for teachers. Because all of these opportunities exist in one easy to use interface, chat has the potential to be a powerful classroom teaching tool.

Using chat, students can work together to solve mysteries, debate political issues, argue court cases, or discuss literature. In the PCF classroom, groups of students used chat rooms to organize their thoughts for presentations that would advise the president to either involve the United States in World War I or remain neutral. Other teams of PCF students used chat to devise debate strategies and to enact a legislative session for a border state that was trying to decide which side to take in the United States Civil War. Chat also served as a medium for solving math problems, which required

students to recognize and use the vocabulary associated with the symbols they more commonly use. Involving partners in a classroom across the county, state, or country can add valuable different opinions that are crucial to effective discussion and debate. Students living in a large city may have very different perspectives on urban development that students living in a rural area might never have considered. While these kinds of activities could be done in a nontechnology environment, a chat facility adds new dimensions to the students' experiences.

The ability to separate student groups can also open new possibilities for student learning. Students in a class can be divided and sent to different classrooms for a lesson about communications. For instance, students in the PCF classroom were split into two groups, with some students staying in the classroom and others moving to a nearby computer lab. Students in the classroom created a figure from blocks which those in the lab were not allowed to see. Using the chat facility to communicate, students (and parents, in this case) in the classroom sent instructions to those in the lab attempting to construct the figure. Students learned valuable lessons about the importance of detail, the difficulties inherent in providing concise instructions, and about the many ways in which written language can be interpreted when visual cues are absent.

The technology component of chat lessons often motivates students. Classroom chat sessions can decrease ambient noise levels, foster good writing skills, encourage shy students who are usually inhibited in group discussion, and improve student skills in cooperation and collaboration. An added advantage offered by the project chat implementation is the automatic logging of student dialogues. If teachers choose, they can make those logs available to students in a format that cannot be modified so that students can print them for a reliable record of their thoughts and plans.

Chat logs can also assist classroom teachers with assessment. In traditional cooperative activities, the teacher has to rely on student reports and brief observations of each group to judge student performance. But with chat, teachers can monitor group interactions without having to be physically present for group meetings. This allows the teacher to grade more accurately, follow student thought processes, identify negative partnerships, and predict successful student combinations. Further, when students know that their participation is being logged and may potentially be reviewed by the classroom teacher, they take more care to fulfill their group responsibilities and conduct themselves in a reasonable manner. If teachers are planning to review chat transcripts, students should, of course, be aware that their sessions are being recorded and will be reviewed.

Chat, however, does not replace traditional cooperative activities in the classroom and may not be suitable for all group work. Chat does not allow for a shared workspace, just shared communication, particularly outside the classroom. Chat facilities work best for planning, strategy sessions, and discussion activities. For example, if students are writing a story or making a poster, a chat facility is not going to be useful in producing the final product. Instead, chat can facilitate students developing position statements on an issue or reaching a consensus on a controversial issue.

Although chat is not suitable for all cooperative activities, teachers will often find traditional strategies for coordinating group work useful in a chat setting. Groups still need a leader or director that is responsible for guiding discussion and will often need a secretary/recorder to keep track of main ideas. Based on experiences in the PCF classroom, when integrating a chat facility in the elementary grades, particularly the first few times students are exposed to the technology, the actual activities or assignments will probably need to be modified to a level slightly below students' normal working level as students will have to be able to concentrate not only on the activity at hand, but also on their written communication skills. While students are becoming accustomed to using the interface, it is important that they be able to complete their work successfully as well as master their new working environment.

When implementing a chat facility in the classroom or for extracurricular use, it is important to contact school administrations so that legal issues can be identified and resolved. Because laws and policies vary across the country it is important to understand them thoroughly so that potential conflicts can be avoided.

Challenges of Chat

While providing a new forum for classroom activities, assessment, student-teacher interaction, and extracurricular student conversation, chat is not without its challenges. Taking advantage of chat capabilities requires an additional time commitment from teachers who are already faced with demanding schedules. Reading over transcripts, analyzing successful and negative student interactions, and planning learning activities will take time that teachers must have available and be willing to give. Additionally, many benefits of chat are derived from its ability to link students and teachers from remote locations and to involve students academically outside of the classroom; thus chats often occur after school or in the evenings, which requires participating teachers to give up additional time of their own.

When teachers participate in chat sessions with the students, particularly from remote locations, they lose traditional ways of preserving their authority, like tone of voice and eye contact. However, teachers can maintain their authority by using formal names and carefully choosing and wording their comments. While effective in preserving the teachers' authority, these techniques were subtle so that students were not affected by the traditional inhibitions of approaching a teacher in person. Chat poses challenges not only to teachers, but also to students. For example, it was often the case that parents would interrupt their children's sessions to make telephone calls.

> Student1: Hey my mom has to use the phone can you hold on aminite
>
> (Approximately seven minutes later…)
>
> Student1: Hey my mom has to use the phone again. I wish she would make up her mind.

Parents treated all chat sessions with the same informality, without distinguishing between schoolwork and casual socialization. This posed obvious problems for students working on homework or extracurricular group projects. Students missed important information and conversation, and often, time had to be devoted to catching those students up so that they could effectively reenter the session.

This lack of consideration and support also poses challenges to overall student use of chat as a social facility. When students are forced to leave the chat room so their parents can use the phone, students must completely log off of the Internet. To return they must establish a new modem connection, log on to the Internet, locate the chat room and log on again. The effort necessary for students to reenter the chat session is a deterrent to using the facility. Hence, once they've logged off, they often don't return.

Logistically, students had difficulties finding each other in the chat room at just the right time. It was not obvious at first that their classmates would log on at slightly different times for a scheduled meeting. With an impatience characteristic of 5^{th}-graders, students logged on and immediately logged off if no other students were online. In fact, during the 4 months that school was in session after the chat facility was introduced, 52 student nonconnections were recorded by the project server while only 42 student conversations took place in the chat room during the same period.

The chat facility also posed significant challenges to those students who found their typing speeds too slow to keep up with the other students

in their session. This is particularly difficult for those students who normally play a dominant role in the classroom but find themselves in the background of a chat session because they can't type their thoughts quickly enough. For instance, in the following excerpt from a chat log, Student1, who was normally a strong leader in the classroom and a strong academic performer, found herself at a disadvantage in chat sessions.

> Student1: I'm sorry but I just can't type that fast and I just feal that you are acting like I'm not there. I'm sorry. I just can't hardly get any ideas in.
>
> Student2: Student1 I proisime well talk too you too
>
> Student2: I PLEASE TALK Student1
>
> Student2: Student1 you are really GREAT HELP Too us,isn't she everyone????
>
> Teacher: Of course you're a big help!!! I really appreciate everybody's participation tonight!!!
>
> Student1: If you want me to get off I will. It's no problem.
>
> Student1: It's really OK if you want me to get off. Just let me know.

Not only was Student1 frustrated, but her peers had to spend a significant amount of the chat session, well beyond what was included here, to draw her back into the conversation and keep her from leaving the session. By the same principle, though, there were students who were uncomfortable verbally in the classroom who enjoyed the opportunity to interact via the computer.

In any forum for student interaction, there is the potential for negative student behaviors, and chat is no different. Project chat logs showed students taking aliases and using those aliases while saying things that probably would not have been said if they knew they were identifiable. Students would also hold down the carriage return key to keep the screen scrolling to prevent other students from reading posted comments. These kinds of negative behaviors did not occur during classroom chat activities or when a teacher was online with them, so academic sessions were free of these interruptions. However, these are serious challenges for students who are trying

to use the chat facility without the influence of an authority figure.

As the PCF chat software was project-developed, it could be modified to prevent many of the unwanted student behaviors. Easy solutions to the previous behavior problems include preventing students from logging into the chat room under anything other than their user name and ignoring blank lines which are input. The ability to change software interfaces rapidly was particularly valuable when the chat application was first introduced. Although this chat application was designed to be as intuitive as possible, investigators discovered unexpected problems with window sizes that caused confusion among students working on computers with small screens. Since the investigators controlled the software design, window sizes could be easily adjusted.

CONCLUSIONS

Using the chat facility, teachers were able to deepen their rapport with students and provide support to students using the chat facility. Chat did change the nature of student-teacher discourse, with chat topics often including less academic and more personal matters. Further, despite scheduling conflicts, students effectively used chat to socialize and coordinate learning activities. Analysis of the chat data revealed several trends related to student perceptions and interactions. Not surprisingly given the highly verbal nature of chat usage, student vocabulary and language scores were strong predictors of chat usage. Girls were by far the most active users with usage decreasing sharply at the end of the school year for all users.

In spite of the challenges associated with chat usage, many of the students in the class chose to take advantage of the new chat facility. However, most of those students had already proven themselves to be self motivated and engaged learners in a wide variety of contexts, including academics and technology. Without exception, all students who were historically unmotivated nonperformers never tried to engage in a chat session. The chat facility, in and of itself, had no impact on the motivation of those students.

References

Ehrich, R., McCreary, F., Reaux, R., Rowland, K., & Ramsey, A. (1998). *Home-School networking to support constructivist learning in a rural elementary school: Lessons from families, schools, and researchers*. Article presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Ehrich, R., & McCreary, F. (1999). *Immersive educational technology: Changing families and learning*. Article presented at the annual meeting of the American Educational Research Association Annual Meeting, Montreal, Canada.

Enochs, L., Handley, H., & Wollenberg, J. (1986). Relating learning style, reading, vocabulary, reading comprehension, and aptitude for learning achievement in the self-paced and computer-assisted instructional modes. *The Journal of Experimental Education, 45*, 345-62.

Means, B., & Olson, K. (1995). *Technology's role in education reform: Findings from a national study of innovating schools*. Washington, DC: Office of Educational Research and Improvement, U.S. Department of Education.

Mohamedali, M., Messer, D., & Fletcher, B. (1987). Factors affecting microcomputer use and programming ability of secondary school children. *Journal of Computer Assisted Learning, 3*(4), 224-39.

Robertson, S., Calder, J., Fung, P., Jones, A., & O'Shea, T. (1997). The use and effectiveness of palmtop computers in education. *British Journal of Educational Technology, 28*(3), 177-189.

Ross, S., Smith, L., Morrison, G., Ericson, A., & Kitabchi, G. (1989 February). The Apple classroom of tomorrow program with at-risk students. In *Proceedings of Selected Research Articles presented at the Annual Meeting of the Association for Educational Communications and Technology*, Dallas, TX.

Schmitz, J., & Fulk, J. (1991). Organizational colleagues, media richness, and electronic mail. *Communication Research, 18*, 487-523.

Sein, M., & Bostrom, R. (1989). Individual differences and conceptual models in training novice users. *Human-computer Interaction, 4*(3), 197-229.

Trevino, L., Lengel, R., Bodensteiner, W., Gerloff, E., & Muir, N. (1990). The richness imperative and cognitive style: The role of individual differences in media choice behavior. *Management Communication Quarterly, 4*, 176-197.

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Note

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