CHAPTER 5:

A HOLISTIC APPROACH TO COMPUTER LITERACY

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"Computer literacy" includes the mastery of machine operations (Bitter, 1982). In many computer literacy courses the mastery of machine operations is taught separately from and prior to computer applications. Students are first taught how to locate machine parts, insert disks, boot programs, manipulate files, operate the keyboard, printer and monitor. Once they have learned machine operations they are introduced to computer programming, usually in BASIC or PASCAL, and then, in advanced courses, to uses such as text editing, spread sheet analysis or data systems management.

The separation of machine operations from computer applications in the acquisition of computer literacy is parallel to the separation of reading readiness from reading in the acquisition of print literacy. Reading readiness is the teaching of the subparts of the reading process, such as sound-letter correspondence, word order and decoding which is taught prior to and independent of engaging in the activity of reading itself.

The separation of machine operations from computer applications is like the separation of reading readiness from reading. Both are atomistic. In both

cases, the assembly of the parts of the task (either machine operations or reading readiness) into the whole task comes after students master the components of the subtask.

The teachers in this project adopted a different, more holistic approach to computer literacy. The teaching and learning of machine operations was embedded within academic activities such as reading and writing. Students were not taught machine operations first and computer uses second. Students were taught "keyboarding," disk management, file production, file maintenance and text editing in the context of academic tasks. In any given language arts or mathematics lesson, students were presented with academic tasks to complete. In the process of learning to write essays, generating school newspapers and composing poems, students were also learning the process of using the microcomputer. Correcting the spelling in a student's letter or writing a Haiku poem on the computer required the student to operate the machine as well as read and write.

The teachers' decision to embed the teaching of machine operations within the teaching of machine uses enables us to examine an important question about computers in classrooms:

> Do students develop computer literacy skills when machine operations are taught within the context of academic tasks?

In order to answer this question, we examine students' naturally occurring trouble shooting routines and their performance on a computer

literacy test. The trouble shooting routines were the procedures that the students employed in cases of trouble or difficulty when working at the computer. The computer literacy test was a functional, hands on examination of students' computer knowledge administered at the end of the school year.

Students are being asked to learn two things at once when they are learning machine operations embedded in academic tasks. An important issue that arises, then, is whether embedding computer literacy training in an academic curriculum facilitates or interferes with learning. It is possible that the students will learn both about the computer and about academic tasks at the same time and equally well. It is also possible that learning to use a text editor will interfere with the process of learning to write. For example, students' productivity, style and fluency might be suppressed by the difficulty they have in learning text editing commands and manipulating disks.

We were able to examine the holistic approach to computer literacy in two ways: (1) by tracing students day-to-day work at the computer from October to June and (2) by administering a computer literacy test to the students in the project classrooms at the end of the school year. We will examine students trouble shooting at the computer center first, and discuss the results of the computer literacy test second.

Trouble Shooting

In previous chapters, we have identified three phases of the work session at the microcomputer, which we called start up, academic and wrap up.

The students' actions within each of the three phases of the computer work session can be conceptualized as a decision making routine. Students must take a series of actions in order to accomplish the task set before them by the teacher.

The Computer Work Session as a Decision Making Routine

The computer work session starts with the most basic machine manipulations; the students must insure that the power is on and load the correct disks. Once the students are interacting with a program, the decisions become more subtle. The students must select appropriate subroutines (writing, printing, inserting text, deleting text etc). The content of students' work is at the heart of the decision making process. Students choose what text to enter. In the case of program controlled software (explained above), this choice may take the form of selecting among preformed phrases or in the case of user controlled software, this choice involves composing words or phrases. Software and hardware choices appear again after students have finished their work. Naming files accurately, saving text, perhaps printing copies, removing disks, turning off power are included here.

This decision making sequence is depicted in Figure 10:

Figure 10: A Computer Work Session Visualized as a Decision Making Routine

key: [or] = a machine manipulation decision
+ = a software manipulation decision
¶ = a content decision

Once students have mastered these steps, the process can become so routine that students' actions do not appear as planned choice or calculations at all. We found it useful nevertheless to characterize the students' interactions with the computer as a decision making routine because doing so facilitated our study of students' learning machine operations embedded in academic uses of the computer.

By focusing on students' actions at each decision making point, the ease and facility of students' progress through the work session could be gauged. Presumably, if students are manipulating disks, selecting programs and engaging the program quickly and effortlessly, then we have a warrant for saying that work session is proceeding smoothly. If, however, students fumble with the power switch, can't load disks, clog the printer with paper and do not work on assigned programs, then we have an indication that the work session is not proceeding smoothly. From this set of assumptions, we make an inference: the more smoothly the students pass over the myriad of decision making points, the better they are performing machine operations.

The warrant for this line of thinking comes from sociological studies of "routine everyday activities" (Garfinkel, 1967) and investigations of what people do when breaks, disruptions or breaches in routine activity occur (Sacks, 1966; Ramos, 1973, 1979; Mehan, 1979: 97-103). Disruptions in routines and the work that people do to re-establish the routine are instructive places to look for an understanding of how people learn to carry out routine work.

When a computer work session is viewed as a decision making routine, there are literally hundreds of decisions to be made. Students traversed the great majority of these decision points with ease. On only a few occasions within a given work session did a student's work routine breaks down. Breakdowns were defined as any disruption in students' work routines. These included:

> students paused to consult printed instructions placed around the computer
>
> students selected the help option available within the computer progran
>
> students asked a teacher, observer, aide or other student for help with a problem
>
> students stopped work to try and solve problems

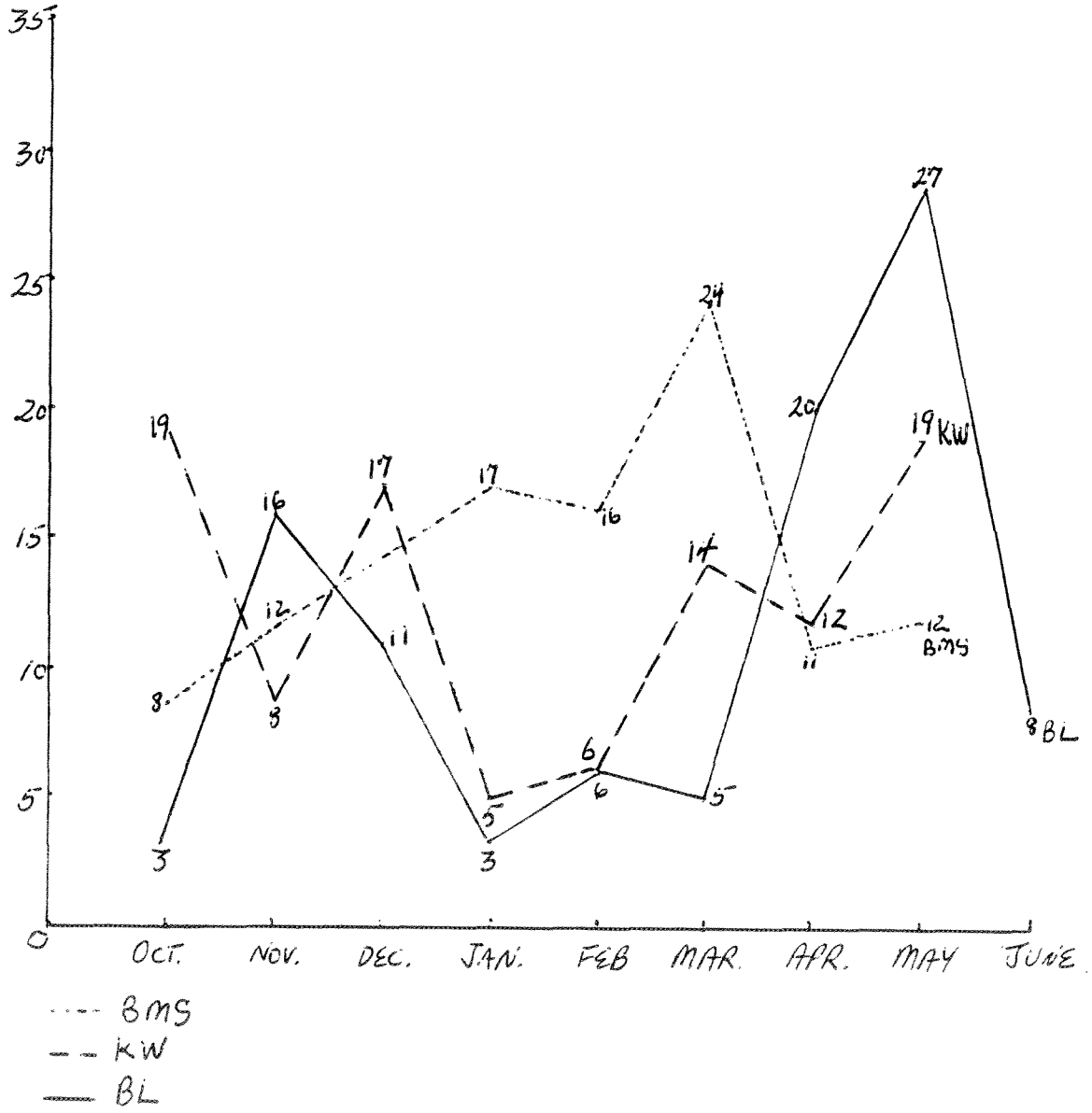
This way of conceptualizing routine work and disruptions in routines caused coding difficulties which may have influenced our analysis. It is easier to hear students calling for a teacher or peer than it is to see students glance at a wall chart or computer screen. Therefore our conclusions about the relative use of social and print resources must be considered tentative.

Calls for Help and Software Complexity

The problem solving routine at the computer center involves decisions about machine manipulation, software and the content of teachers' assignments. We wanted to know whether students' difficulties were related in any way to the kinds of decisions that they had to make during the course of a computer work session. One could imagine that students would have less trouble with machine operations, software management and content choices as

they gained more practice at the computer center. To examine this issue, we calculated the number of calls for help per work session for each month in the three classrooms. The results are displayed in Figure 11:

Figure 11: Percentage of Calls for Help



There is no clear temporal pattern in the three classrooms. While we did not see a linear decline in calls for help during the school year, we did discover a powerful relationship between the type of software assigned and students' calls for help. Differences in the number of calls for help per month was a function of changes from one type of software to another.

All three teachers started the year by introducing their students to "program controlled software." As students mastered the academic tasks inherent in these programs, the teachers introduced software that shifted control to the user. As we explained in Chapter 4, program control and user control software place different cognitive demands on students. When using program controlled software, students insert a disk, select a program from the menu which is presented on the monitor, and form a story or a poem from choices provided on a list. Disk management is limited to a single disk; program management is limited to single letters, the return key and the Control-C function.

Writing with user control software is more complicated. Students must manipulate two disks in order to boot up the programs. While they still choose a program from a menu, they must use more program management keys. In addition to return key and Control-C functions, students must know (I)nsert and (D)rop commands while composing text.

Editing text is even more complicated. Students must master all the disk management operations and program management operations associated with writing, and be able to move the cursor using arrow keys, the Control-I

function or jump commands. Disk management is also more complex. Files must be named at the end of a work session and be located on one of a number of disks at the beginning of a new work session.

When the type of software that the students used in a given month is considered, then a pattern of student learning emerges. As Figure 11 shows, students generated 8% of all calls for help in BMS' classroom in October. During this month, they were exposed to Program Control software such as Apple Presents Apple, Science Fiction Story and Master Type. In the following month, they were exposed to The Writer's Assistant, a user control program for composing poems and essays. The percentage of calls for help rose from 8% to 12%. The students continued to use this software for the next two months. There was a slight increase in the number of calls for help during this period, 17% of all calls for help occurred in January, while 16% occurred in February. In March, BMS increased the complexity of the students' tasks at the computer. They participated in Computer Chronicles Editorial Boards and became responsible for editing students' newspaper stories. There was an accompanying increase in students' calls for help during this period; 24% of all calls for help occurred then. Students continued to write and edit for the remainder of the year, and we see a decline in students' difficulties during the final months of the school year. Only 11% of all calls for help occurred in April and 12% occurred in May.

A similar pattern existed in KW's classroom. She introduced her students to Storyland and Apple Presents Apple in October; the students registered the most calls for help during this month. In November, the task shifted to editing previously written text; we found a decline in calls for

help from 19% to 8%. In December, another new task was introduced. Students were called upon to write on their own; the calls for help increased from 8% to 17%. The assigned task between January and April was similar to that assigned in December, and we found a decline in calls for help. The students averaged 9% calls for help during these months. During May, KW changed the task from writing to editing on the computer; we found the same increase in calls for help in this classroom as we found under similar circumstances in BMS' classroom. Twelve percent of the calls for help occurred in April (when students were writing at the computer) while 19% of calls for help occurred in May (when the students were editing at the computer).

The age of the students in BL's classroom had an influence on the relationship between students' mastery and software complexity. Her students had more trouble mastering the program control software than did the older students in BMS' and KW's classroom; 27% of calls for help occurred in November and December. BL continued the use of this software into the Winter months, and gradually moved the students down the continuum of control by using software like the Horus stories and Storyland. We found a sharp decline in calls for help during these months; 3% of calls for help occurred in January, 6% in February and 5% in March. In May, BL introduced the students to composing stories at the computer. This shift from program control to user control software was accompanied by a sharp increase in the students' calls for help; 27% of all calls occurred in May.

In general, students experienced initial difficulty with computer operations and program manipulations, and then gained control of them. The

shift to a more complex task was accompanied by an increase in students' difficulties as indexed by student calls for help. As students worked with the more demanding programs, they mastered more complex routines.

The Transformation of Problems

The relationship between students' mastery of computer operations and the complexity of software is even more pronounced when the type of errors that students made through the school year is considered. Students did not ask people to help them with the same kinds of problems throughout the year. They called for help with more sophisticated and subtle aspects of computer and software operations as the year went on. Recall the conception of the work session as a decision making routine depicted in Figure 10 above. In these terms, students at first ran into trouble with the first and last steps in the computer using process, then had trouble managing the software, and finally had trouble with decisions about the content of their entries.

Program Control Software and Computer Operation Difficulties. When students were first exposed to the computer in the Fall of the year, they ran into trouble with initial steps in the computer using process. They did not know how to turn the power on; they inserted the disk in the disk drive upside down. They expressed concern at the "blinking red light" on the disk drive; since it was red, they thought there might be danger. The blinking cursor also led some of the students to express dismay. They often had trouble going through the sequence of steps involved in booting a program. Once they booted a program, they had trouble locating a program on the disk.

Saving and printing text at the end of a work session also caused students considerable difficulty in the beginning of the year. They often tried to save a file with the wrong disk in the drive. They didn't know whether they should print a file or not.

Initial Use of User Control Software and Software Manipulation Difficulties. The introduction of new and complex software into the students' learning environment introduced new and more complex problems for the students to solve. These new problems did not seem to be added on to previously existing problems, however. Instead, what had previously been considered to be a problem was mastered and became routinized. Old problems were replaced by new ones.

When students graduated from program control software to the initial stages of user control software the source of their problems shifted as well. By November in KW's classroom, December in BMS's classroom and January in BL's classroom, students had the steps in the Start Up and Wrap Up phases of the computer work session under control. There were fewer calls to adults to help with disk insertion, on and off switches and disk selection. Students had less difficulty getting the machine ready for work. Now calls for help focused on the use of software, not on the use of the machine.

Once they booted a program, students constantly forgot to press the keys that shifted the program into different modes (e. g., the I key for inserting text, or forgot to press the return key after text had been entered). Another recurrent type of problem that plagued students when they first encountered user control software was accidently pressing incorrect keys and not knowing

how to recover from the situation. The Control-C key (which signals the completion of a computer operation) was often pressed instead of keys that enable text to be inserted (i. e., Control-I). Or students attempted to enter text without setting the computer to the insert mode. When students began pressing keys to enter text, the computer, not set to accept instructions, often threw the students into strange places, including program language.

When students finished working on a text file, they were instructed to name the file according to certain procedures so they could find their work at a later date. Naming and locating texts that had been named previously caused students difficulty at this stage in the development of their computer mastery. Likewise, they confused the disks that controlled programs with disks that stored students' files. These problems, which are concerned with more technical aspects of machine operations, accounted for the bulk of the calls for help from students to adults when students first encountered user control software.

User Control Software and Difficulties with Editing Commands

Concommitant with the shift to composing texts and editing them at the computer (tasks at the "user control" end of the software continuum), we found a shift in the situations that caused students trouble, which in turn led them to call for help. For example, the students had problems throughout the year with the editing commands of the word processing system. However, the nature of the problem shifted from those associated with initial processes (e. g., beginning to type without first pressing the appropriate

command key--Control I for (I)nsert, or forgetting to press Control-C when ending an (I)nsert, to problems of a more conceptual nature. Evident when students began writing and editing were problems such as:

> Adding new text at the end of a line when the cursor won't move past the end of the text;
>
> Moving sentences or larger units of text;
>
> Adding space between blended words or sentences (e. g., between the two e's in Theend);
>
> Exchanging text within a sentence (e. g., text for test);
>
> Aligning the title of stories or poems in the center of the page.

While students spent time wrestling with these problems, their previous difficulties with program booting and final machine operations did not continue to plague them. These problems had been solved, and were now incorporated into the routine of the work session.

The Use of Social Resources in Trouble Shooting

Another way to look at students' mastery of machine operations and uses is to consider the sources that students consult when they need help. In order to obtain this information, we computed the number of times that students stopped the routine of the work session, and "called for help" with their work. We then determined where students turned for help when these disruptions in their routines occurred. This information is presented in Table 2.

Source of Help

	Adults			Students		Written		T/E	
	Tchr/Aide	Obs	Tutor	Partner	Peers	Instr	Screen		T
Classroom									
KW (N=315)	23%	30%	05%	07%	07%	18%	04%	06%	100
BMS(N=450)	11%	58%	--	09%	05%	11%	04%	03%	100
BL (N=258)	12%	55%	01%	06%	01%	11%	04%	05%	100

Table 2: The Sources of Students' Calls for Help in Computer Work Sessions

[key: Tchr/Aide--Teacher or Aide T/E--trial and error; an
Obs--Observer from Research Team individual search]

The students in all three classrooms called upon the observer most frequently, and the teacher second most frequently, when they needed help. Students turned to the written instructions about computer use posted around the work station third most frequently. The student's partner was the next most frequent source of help when difficulties arose in KW's and BMS's classroom, while instructions available on the computer screen were the next most frequently called upon by BL's students. In short, social resources were the most predominant source of help when students ran into trouble at the computer.

The predominance of social resources becomes even more apparent when the categories in Table 2 are collapsed as in Table 3 below:

Sources of Help

	Adults	Students	Printed Instructions	Trial and Error
Classroom				
KW	53%	19%	22%	6%
BMS	69%	14%	15%	3%
BL	67%	08%	20%	5%

Table 3: Major Categories of Calls for Help

Here we see more starkly that adults were called upon for help most often. Printed instructions were consulted more often than peers were called upon, but the calls for help to adult and student sources combined far outweighed consultations of instructions posted at the computer and available on the computer screen.

The relatively infrequent use of information sources in these classrooms is linked to the problem solving theme discussed in the cognitive sciences literature. One need look no further than Simon's (1949) Administrative Behavior for a discussion of the use of convenient strategies in problem solving. He describes "satisficing" as the way that people solve problems which involves the selection of the first available option or solution that gets a job done. Satisficing is often contrasted to "optimizing" or other formal operational procedures in which the problem solver is expected to run through the full range of all problem solving routines, selecting the best one, not just any one that will do. With his

emphasis on satisficing, Simon is pointing to the practical element in problem solving; people do not necessarily employ the optimal problem strategy if a suitable and convenient one will do.

The students at the computer had a range of options available to them in time of trouble (teachers, observers, aides, other students, instructions on the screen, instructions posted around the computer and each other). From the standpoint of the teachers' long term goals for students' learning, the selection of written instructions or individual problem solving (what we have been calling "trial and error" here) would be seen as optimal. Yet the students overwhelmingly called upon the observer and the teacher which were much more convenient and immediate ways to solve problems.

Social Resources and the Local Expert

Our finding that students turn to social resources rather than printed materials or on-screen instructions when they have trouble working at the computer is consistent with recent work in the field of human-machine interaction (Bannon, personal communication, 1985; Norman and Draper, 1975). Scharer (1983) reports that only 10-15% of several dozen data processing trainees who were taught using long and thorough user guides consulted them during initial training and in work sessions observed 6 months after the completion of training. Instead of consulting manuals, the trainees listened carefully during demonstrations and took notes. Notes were referenced continually, but the manual was not. Within each group of trainees, one or two quickly understood the material and became local heroes by helping others. Most of this teaching was "show and tell" not "write and

read."

This pattern of relying on "local experts" accompanied the trainees when they finished training and went to work. New users were trained by more experienced users, again by show-and-tell rather than through manuals. People who had learned the system were consulted for answers to pressing problems. These local experts were not necessarily in positions of institutional authority; they had developed local and relevent knowledge and were called upon when needed.

In Scharer's terms, the students in our project's classrooms were treating the observers, teachers and some times each other as local experts. The observer was known to the students, afterall, to be a knowledgeable computer person and was sitting within 5 feet of the students at the computer center. And teachers are the conventional source of knowledge in students' eyes. When students were called on, those who had just completed a work session at the computer center were most often treated as local experts. Students who were having trouble sought out students who had recently left the computer center for advice, perhaps using the logic that they may have encountered and even solved similar problems.

When local experts responded to students' calls for help, they, like the adults in Scharer's study, adopted a "show and tell" and not a "write and read" mode of instruction. They sometimes took over the keyboard from the students who were in jeopardy and performed the operation that was causing difficulty. They also demonstrated the relevent operations so that the

jeopardized students.

The mode of instruction that developed between local experts and students has more in common with informal education (Greenfield and Lave, 1983; Scribner and Cole, 1973) than it does with the formal mode of instruction usually associated with one classroom. Students learning from each other and other local experts employed the show and tell, observe and demonstrate techniques that are associated with expert weavers and tailors teaching their apprentices. They did not employ the verbal mode of instruction they so often encounter with their regular classroom teachers.

Summary

Pairs of students at the computer worked together on language arts tasks. The students made a series of decisions in the Start Up, Academic and Wrap Up phases of the computer session in order to complete the assigned task. For the most part, students were very efficient in carrying out this decision making routine. Students checked the power source, loaded the correct disks, selected the appropriate program, chose the appropriate sub-routine within the program. When finished entering text, students made files, printed copies, removed disks and turned the power off.

On some occasions, the smooth and fluid flow of the work routine was disrupted. Students had difficulty operating the machine, handling the software or deciding what to write and how to manipulate software commands in order to write. We found that these disruptions, or breaches in routines, were productive places to look for information about the organization of

routine interaction.

When students had difficulty with machine operations, program manipulation or text editing commands, they called for help. The adults in the classrooms--teachers, observers and aides--were called upon most frequently by students when they ran into trouble. The instructions about computer use posted around the computer center were the next most frequently consulted resource when students called for help.

Measured in terms of sources consulted in time of trouble, at least, the students in these classrooms can be characterized as choosing the most immediate and available solutions when problems in the decision making routine at the computer arise. The use of this "satisficing" strategy resulted in the exploitation of social resources in the form of local experts.

In order to determine whether students' difficulties were related to the kinds of decisions that students had to make, we considered whether students had fewer difficulties as the year went on, that is, as they gained more experience at the computer. While we did not see a linear decline in calls for help over the course of the school year, we did discover that the complexity of software had a strong influence on the frequency of students' difficulties. Students experienced more difficulty and called for help more often when they were introduced to software that placed greater cognitive responsibility on them. Students' difficulties (as indexed by their calls for help) increased in the months in which the teachers shifted from program control software, i. e., in which the students had to manage only one disk

and formed stories and poems by selecting options from pre-determined lists, to user control software i. e., in which students had to manipulate more than one disk, name files and enter text free style. The initial difficulty that students experienced when introduced to more complex software diminished. As students worked together with the more demanding software, they mastered the new and more complex routines. Their calls for outside help declined. Thus, instead of a straight line decline in students' reliance on outside help, we found a more jagged learning curve. When confronted with more complex software, students' difficulties increased initially, but declined as they entered new skills into their work routine.

The students' mastery of more complex computer routines was made more visible when the types of errors that the students made throughout the school year was considered. Students did not call for help for the same kinds of problems in the Spring as they did in the Fall. They called for help with more sophisticated problems as the year went on. In the Fall of the year, when user control software was used, the students had difficulty with the first and last steps in the computer using process, i. e., machine operations. In the middle of the school year, students had trouble with the stages of the decision making routine associated with software manipulation, i.e., naming and retreiving files. At the end of the school year, the students had most of their difficulties with subtle editing routines, such as adding new text, exchanging new text for old, and moving text from one part of an essay to another.

Thus, while students continued to rely on social resources throughout the school year (i. e., during the shift from program control to user control

software), they did not call upon help for the same problems. The calls for help were about more technical problems later in the year than earlier in the year. This pattern of trouble shooting is an indication that the students obtained a deeper level of understanding about the software and the computer through their experience with a holistic approach to computer literacy.

Testing Computer Literacy

This examination of students' trouble shooting routines in naturally occurring work sessions at the microcomputer gives us considerable insight into the utility of teaching computer operations within the context of computer uses. These results are reinforced by our examiniation of individual students' performance on a computer literacy test.

Members of the project designed a functional computer literacy test which was designed to measure students' knowledge of computer functions and ability to use the computer. It was a "hands on" test. Students performed actions at the computer in response to questions asked by a member of the project staff.

Part I consisted of eight questions about the parts of the computer system. Students were asked to label computer components and explain their function. Questions were included about computer parts that had never been mentioned in the classroom like the Central Processing Unit. Complete or perfect answers were awarded 2 points, incomplete or partial responses were given 1 point. No responses or incorrect responses received 0 points.

Part II required the student to use the software to enter text, save the text on disk and print a copy of the text. This involved a sequence of about 10 steps. A perfect score of 20 was given to a student who was able to complete the sequence with no help or prompting from the tester. One point was subtracted if prompting was required for any step. Two points were subtracted for any step that the tester had to do for the student or direct the student to do.

The last section of the test consisted of questions and student demonstrations. The students were asked to edit the work of another person. The textfile stored on a disk used a coding system that was different but similar to one that they had used in their classroom. Once they had located the file, the students were asked to make certain changes. Students' answers or actions were scored as either correct and/or efficient (2 points) or incomplete and/or inefficient (1 point).

The computer literacy test was given to six students in KW's and RR's classrooms, 4 in BMS's classroom and 5 monolingual and 6 limited English proficiency (LEP) students in BL's classroom. The students were selected in the following manner. The class list for each of the classrooms was reviewed and any student for whom we did not have a complete set of pretests was excluded. Teachers were then asked to group the students into three categories, students who seemed to be doing well on the computer, students who were average, and students who seemed to have more difficulties. Two students were selected from each of the groups based on coordination of the student's free time, the tester's schedule, and the availability of the computer.

The test was administered individually. Students were told they would be asked about things they had not learned. Students took from 30-40 minutes to complete the test. The test consisted of three parts: (1) knowledge of computer vocabulary and computer functions, (2) demonstration of ability to enter, store and print text, (3) demonstration of ability to edit text. (See appendix for a copy of the test).

While many of the students achieved perfect scores on Part II, there were no perfect scores on Part I or III. This was because the students were asked to give information or demonstrate procedures that they had never before encountered in classroom instruction. In fact, the teachers questioned the inclusion of items that they were sure their students would not know. They were included to give students a chance to demonstrate their ability to make inferences from what they did know, and to utilize information that is available from the software.

Table 4 shows the average number of points scored by the students in each of the classrooms.

Table 4:
Students Average % of Correct Responses on the Computer Literacy Test

	Part I: 32 points	Part II: 20 points	Part III: 39 points	Total 91 points
3rd-4th (BL)				
Bi-lingual n=6	41	43	22	33
English n=6	59	51	33	46
Total	49	47	27	39
4th (BMS) n=4	69	90	54	67
5th-6th (KW) n=6	78	95	56	73
5th-6th (RR) n=6	74	99	80	82

With the exception of the youngest bilingual students, almost all of the students were able to demonstrate how to write, store and print text with little or no prompting. In addition, most of the students had learned the terms and functions of most of the computer parts, peripherals and software, even though they had received no direct computer literacy training. They were all familiar with the basic editing commands, and many of the students were able to demonstrate one or more advanced editing commands that had not been taught by the teacher.

The test results of the students are congruent with their observed performance on computers in the classrooms as well as the teachers evaluation. The younger students (BL's students) had the most difficulty mastering the software over the course of the year. They scored the lowest on the test. (Some of the reasons for this have been dealt with in more detail in Chapter 3.) These students scored highest in Part I, which dealt with knowledge of the computer's parts and functions. It appears that they were able to learn almost as much about the system as the older students even though they experienced more difficulties in using it.

The highest scores for the more proficient students are in Part II of the test. The discussion on trouble shooting earlier in this chapter indicated that the calls for help at the beginning and middle of the year were concerned with issue of writing, storing and printing textfiles. These tasks remained difficult for the 3rd-4th graders in BL's classroom even at the end of the year. In the upper grades, the students learned how to do

these tasks so well that there were many perfect scores in this part of the test. This performance as well as the decrease in calls for help concerning these procedures indicate that these students, with a wide range of classroom skills, had all mastered the mechanics for writing with the computer.

The performance on Part III indicates the students' control of the computer for editing and revising texts. Editing and revising were introduced midyear; they are skills that students slowly acquired over the last months of the school year. Many of the calls for help during the later part of the year dealt with problems that the students had with the more difficult tasks of editing. The students were scored not only for accomplishing tasks on this part of the test, but also for doing them in the most efficient way. For example, using the space bar to move to a location several lines away was not scored as high as using the RETURN or down arrow keys. Similarly, using one command to make a change was scored higher than accomplishing the task with two or three commmands.

Another indication of the students' mastery of the technology is the ease with which they were able to handle changes in the system. Students in BL's and RR's classroom were tested with computer systems that were slightly different than those that they had used in their classrooms. In BL's classroom, the students were tested on an Apple II+ computer instead of the Apple IIe they had used all year. This switch in hardware presented students with new experiences. For example, when the students could not find the up/down arrows they were told to use the o and l keys. They were able to make such adjustments with no difficulty. In RR's classroom,

students who had worked with a two drive computer system were tested on a one drive system. They were able to follow the directions in the software for removing and replacing disks even though they had never followed the sequence in the classroom.

The students' overall performance on this test indicates that students learned the vocabulary and functions of the computer components and how to use a word processing system for entering and editing text.

Conclusions

School districts are developing entirely new curricula for teaching students about the operation of the computer. Many of the courses in computer literacy curricula teach machine operations separately and distinctly from the uses that the computer can have for academic and occupational purposes.

Four teachers taught their elementary school students about computer operations within the context of teaching them about computer uses, including writing and editing. Students spent on the average of 25 minutes a week in language arts and 25 minutes a week in mathematics at the computer. This means that they had 15 hours at the computer by the end of the school year. The students in these classrooms learned to write and edit using a microcomputer, and, they learned to operate the machine without a specific and special course designed to teach them about the machine.

If our modest results can be replicated, they have broad implications

for teaching computer literacy. This study suggests that it is not necessary to develop a special, separate and independent curriculum called computer literacy. Instead, the teaching of machine operations can be embedded in the teaching of academic tasks. We have had some success placing computer operations within a language arts curriculum. The same principle should also apply to math, science and social studies.

In addition to being cost effective, the holistic approach to computer literacy takes advantage of the highly motivating characteristics of microcomputers (Malone, 1981). Students are exposed to information about computers while using them to learn important educational material. If computer literacy is decontextualized by having students learn about the computer without leaning what it can do, then the motivating elements can be lost. In so doing, we fear that computer literacy requirements can become yet another academic hurdle for students to jump over rather than being a meaningful educational experience in which usable skills are taught in understandable ways.

Computer programming plays a different role in this holistic approach to computer literacy than it does in many computer literacy curricula. Instead of making computer programming the single entry point and pinnacle of computer literacy, we are suggesting that it is important to provide students with "multiple entry points to expertise" (Levin and Souviney, 1983). Multiple entry points enable students to use computers as powerful tools for a wide range of applications. For some students, that power will come through the ability to program the computer. But, for others, that power could and should come, we feel, from knowing how to use the computer, to write and edit

text, to create music, graphics and animation, to organize information and to communicate it to others. Furthermore, one avenue of access does not preclude another. Just as the student who begins learning about computers by programming them is not precluded from assembling spread sheets later on, so, too, the student who learns text editing first is not precluded from learning to program later.

Like other investigators of human-machine interaction, we found that computer users consulted social resources more often than printed materials and manuals. There are lessons to be learned from these observations about the nature of instructions given to students who are learning to work at computers and the design of user guides.

While thorough users' guides and brief instructions must continue to be available to people learning to operate the computer, it does not seem to us that manuals should be the primary resource in teaching. Instead, teachers can capitalize on the seemingly ubiquitous presence of local experts. In each of the classrooms there were students who were highly motivated and knowledgeable about computers; we are recommending that teachers systematically exploit this expertise by encouraging students who are learning about computer operations to seek out these "computer tutors" (as KW called her local experts).

It is also possible to empower students with knowledge about the computer. Diaz (1984) has been exploring this idea in an after school program in South East San Diego. He selects students who have been having academic difficulty or have not routinely enjoyed high prestige in the eyes

of peers and gives them special knowledge about computer operations. Other students soon learn that they can obtain special help from these experts. The resulting transactions seem to be mutually beneficial; the students in need of help gain it, and the previously unsuccessful student gains experience with success.

While calling for the systematic use of expert students in the computer center, we are not recommending the elimination of written instructions or manuals entirely. Particularly helpful are brief instructions which can be arranged around the keyboard and monitor. The project teachers started the year with general instructions about machine care and basic text editing commands. When they started a new activity, they posted specific instructions that were relevant to the new task on or near the computer. By the end of the school year, the computer was quite literally papered over with notes, reminders and penciled in notations. To a visitor or first time user, the computer and its paper cloak seemed imposing if not impossible to fathom. But students, socialized into each new layer of activity with its accompanying instructions, seldom had difficulty in consulting the appropriate special note, even though it may have been buried beneath weeks of similar kinds of notes.

In addition to a brief list of generic commands and specific lists of instructions, our experience tells us that a different kind of instruction also needs to be posted at the computer center. Diagnostic instructions need to be available to students. These diagnostic instructions take the discourse form of "if you have a problem, then do x." Two such diagnostic instructions used by KW with her 5th and 6th graders are duplicated below.

GET ME OUT OF HERE

If you need to "get out" of a program or back to the beginning, try these in order.

- Push ESC
- Push Q
- Push CONTROL & RESET
- Push PR#6

NO LUCK?

CALL

COMPUTER TUTOR

Warning! DO NOT turn the computer off

WHEN IN DOUBT

(Help Me! Help Me!)

If the computer is not doing as you think it should, try one of these before you call a computer or a teacher

- Is it plugged in?
- Is it turned on?
- Is the monitor on?
- Did you push RETURN?
- Did you push CONTROL-C?
- Did you read the screen for further directions?

If you can answer, "yes," to all of these questions and you still can't get results...

CALL COMPUTER TUTOR

The intent of diagnostic instructions is to encourage students to first, initiate locally organized trouble shooting routines on frequently occurring problems, and second, initiate calls for social help in a prescribed sequence. Peers and computer tutors are to be consulted before teachers. Specifying the order of calls for social help is intended to lessen students' dependence on the teacher and foster student initiated actions.

CHAPTER 6:

FUNCTIONAL LEARNING ENVIRONMENTS FOR WRITING

Margaret M. Riel

When considering the educational applications of microcomputers in classrooms, the issue is how they can be used to achieve important educational goals, ones that could not be achieved as readily without them. Dewey (1916:118-129) claims that educational activities are appropriate when they begin with the experience of students and, through a planned sequence of steps, move in the direction of what experts know and do. Educational goals are flexible guides to activity for Dewey, easily modified by learners and teachers alike.

We began by exploring the educational goals of the teachers in language arts and tried to find ways to use the computer as a tool to accomplish them. One goal of language arts instruction formulated by the teachers was the integration of reading and writing activities throughout the curriculum, the view that reading and writing are coordinated. From this point of view, reading is not confined to reading circles. It is carried out and encouraged throughout the school day, during "reading time" as well as in content areas such as social studies and science. Writing plays a major role in such a language arts curriculum. Students are given time to write in personal journals, compose essays on topics generated by the teacher and write about what they learn in science and social studies.

Another goal stated by the teachers was to help their students to understand writing as a process from initial organization of thoughts to a final copy produced for a particular audience. Realizing that adult writers do not produce finished drafts in one sitting, they wanted their students to be able to organize and collect ideas for writing, create a draft, receive feedback from others, and work it through final editing and revision--a process that unfolds across several working sessions (Miller-Souviney, 1985).

In close collaboration teachers and researchers sought to create activities which extended the interests and experiences of students in ways that accomplished the educational goals of their teachers. This coupling of student interests with educational goals become the basis for creating what we have come to call "functional learning environments."

A Functional Learning Environment: The Computer Chronicles

Functional learning environments in language arts are those in which reading and writing are organized for communicative purposes, rather than just as an exercise for a teacher to evaluate (cf. LCHC, 1982; Newman, 1984). We used a computer network, the "Computer Chronicles Newswire" (Levin, Riel, Boruta, & Rowe, 1984; Riel 1985) to explore the use of the microcomputer to support reading and writing for communicative purposes. Via the Computer Chronicles Newswire, students were connected to a distant, inaccessible audience with which they wanted to share ideas. This writing for communicative purposes and not just writing on a microcomputer had positive effects on the writing process.

The Computer Chronicles Newswire is a writing network that links together schools in different locations, including Alaska, Hawaii and California. Students from classrooms in each of these locations wrote and edited stories about local events which were stored on floppy disks. The disks were sent to all sites participating in the network. Students at each site used articles written by themselves as well as by other students in the network to publish their own local version of the Computer Chronicles Newspaper. Each of the classrooms in our project was connected with each other and other schools in this news network. All the students were involved in writing newspaper articles which they hoped would be published in their newspaper, as well as in other school papers. This activity facilitated the teaching of writing as a process (Cooper and Odell, 1978; Graves 1978) including pre-writing, planning and organizing, writing, response, revision and evaluation and post-writing phases.

The students in the project classrooms were involved in a writing environment that was similar to that of professional writers. The Computer Chronicles News Network was explicitly modelled on existing news wire services. Whenever possible, students' attention was called to the parallels between their work and the work of newspaper reporters and editors. Like adults, their writing was constrained both by the audience for which they wrote, and format requirements of newspaper stories. The quality of the student work was judged by peers and the need for revision was made a natural part of the cycle.

Interactive software which provided the student with suggestions and writing guidelines was used to provide them with "dynamic support" in the pre-

writing and composing phases. It helps narrow down the subject of their articles by making choices. Once the students were ready to write a particular type of story, they were given appropriate guidelines or suggestions. The software helps extend the "pre-writing" phase into the writing of the first draft.

While the computer and printer were important tools in the creation of their newspaper, these tools were used as one part of a larger activity. Many of the learning experiences involved in creating a newspaper took place away from the computer. Students met in small groups to edit each others work and to read, evaluate, and select articles for their newspaper. This project provided a way to integrate computer use with a range of language arts and social studies activities.

The Effectiveness of Computer Supported Writing Environments

In the following sections, we will examine student performance to see whether the creation of a functional learning environment had an effect on students' reading and writing skills. Data collected from four classrooms (described below) will be used to address the following questions:

What effect do functional writing environments have on the writing fluency of the students?

What effect do functional writing environments have on the quality of students' writing.

What effect does collaborative writing and peer review have on the students' writing abilities?

Each of these questions will be addressed separately, employing four different forms of data, (1) standardized testing administered by the school districts, (2) Pre- and Posttest measures collected as part of the project assessment of students' skills, (3) samples of the students' classroom work written on paper and on the computer and (4) audiotapes of editorial board discussions.

Standardized Testing: California Test of Basic Skills

The California Test of Basic Skills (CTBS) is a standardized test that is given by school districts to all elementary school children at least once a year in September or May. CTBS gives students' grade level equivalents in the areas of math, reading, language arts, science and social studies, as well as an overall score. Some of the schools tested only a portion of the students or used only some of the subtests. Two of the project classrooms, BMS's fourth grade and KO's fifth-sixth grade, had test results in all areas for most of their class.

Writing Pre- and Posttests Essays

We were particularly interested in descriptive writing because of its importance in writing newspaper articles, an activity present in all classrooms. We selected two descriptive writing tasks, one asked students to describe a pet and the other asked them to write a news report about a school event. Since the description of an event at school was more closely related to students' newspaper writing, we expected to see the most change in this pair of essays. These are the two writing prompts used:

Description of a school event Imagine you are a reporter for a national newspaper. You have been asked to write a story about something that has happened in your classroom or at your school. It could be something that happened in your reading group, during math time or on the playground. It could be about a special visitor that came to your class or school, a class activity or a school assembly. Think about what happened, who was involved, when it took place and why it happened. Write a story that tells other students about this event.

Description of an animal Imagine you have been given a new pet. Perhaps you have been given a cat, dog, rabbit or a fish. Think about how big the pet would be and what color it would be. Think about how all the parts of the pet would look. Also think about what noises the pet would make and about how the pet would feel when you touched it. Describe the pet you have been given. Tell how that pet would look, sound, and feel.

All students were given the assignments by their classroom teachers at the beginning and end of the year. The students worked individually and the essays were written on paper. They were not timed; the students were given as long as they needed to write the essays.

The length of an essay was determined by counting the number of words in the body of the essay. The title and any byline information were not included in the word count. Numbers were counted as words. The quality of the essays was determined by a method of "holistic" scoring described in Grubb (1981). The tests were scored by three persons who did not know the students. The writing samples were given a score from 0-4 using a four point evaluation rubric for descriptive writing (Grubb 1981:29-33):

0 was given to a composition that did not address the prompt
1 for an inadequate composition
2 for an adequate composition
3 for a good composition
4 for an excellent composition.

The evaluation rubric is in the Appendix.

The scores given by each of the three readers were averaged. These

scores form an ordinal scale which are very similar to the numerical values given to grades. We will report "grade point averages," acknowledging that the scoring is ordinal in nature in that the difference between the values may not reflect the same degree of improvement.

Classroom Writing Assignments

The students' writing samples over the school year provide further evidence about the influence of functional activities on the length and quality of students' essays. Teachers were asked to provide a sample of students' work about once a month. When possible, the assignment was collected on the days that videotaping was done in the classroom. All the writing samples discussed in this section were written by individual students on paper.

The length of the essays were determined by counting the number of words in the essay (excluding titles and bylines). Papers for which a word count was not appropriate, such as poems and responses to a series of questions, were not included in the sample. The papers were grouped into three periods, Sep-Dec, Jan-Mar and Apr-Jun, and the average length of papers written in each period was computed.

The essays scored for length were then scored for quality by using the following modified holistic scoring technique. The teacher's reported goals for the assignment, as well as the directions presented to the students, were used to determine the writing prompt. A four point

'evaluation rubric" was selected from Grubb's (1981) that was most appropriate for the form of writing (descriptive, narrative, expository or persuasive). One scorer assigned 0-4 points to each essays based on the evaluation rubric. The average score of the papers written during each of the three periods, Sep-Dec, Jan-Mar and Apr-Jun, is presented in the discussions of quality of writing in each of the classrooms.

Writing in the classroom on the Computer

It was more difficult to determine the set of essays written with the computer because the students almost always worked in pairs on the computer and partners were changed. Rotating partners gave students opportunity to work with a range of other students, but made it difficult to assess individual improvement. Assignments took longer to complete because of limited access to the computer. Some of the writing activities involved interacting with partial texts provided by the computer program. Papers written earlier were revised during a later period.

At the same time students completed a number of different writing activities on the computer over the year, all classrooms participated in some form of newspaper writing. To avoid some of the confusion of dealing with different revisions of an article, we used only the final copy of articles selected by the students for publication in their classroom newspapers. This enabled us to compare the length of computer generated newspaper stories with those written on paper by the students in KO's classroom which did not have a computer.

The different editions of the newspapers from each of the classrooms

were used to assess changes in length. Only stories in paragraph format were used for word counts, a choice which excluded all jokes, recipes, poems, puzzles, survey reports in table form and interview transcripts. With the exception of the newspaper from BL's class, all newspapers included stories written by students from other classrooms.

The modified holistic scoring procedures describe in the previous section were used to rate the newspaper stories on a 0-4 point scales. All articles that were scored for length were also scored for quality.

Four classrooms participated in this study. In three classrooms, the teachers used computer writing tools to teach language arts. In one classroom, the teacher taught reading and writing in a way which was similar to the other teachers, but without the aid of the computer. Differences in the age and ability levels of the students and differences in teacher knowledge and experience make it necessary to report on each of the classrooms separately.

Description of Writing in BMS Fourth Grade

BMS began the year with many resources for integrating the computer into the writing curriculum. She had been trained to teach writing as a process through the San Diego Area Writing Project's Summer Institute Program and had experience implementing this approach with students at different grade levels. She also had prior computer experience and had used and created Interactive Tool software.

The majority of students in her class were of average achievement in language arts and reading as measured by the California Test of Basic Skills. She also had a number of limited English proficiency students.

As described in Chapter Two, BMS taught writing in a series of steps. She began by introducing the assignment and then helping students either together or in small groups to collect their ideas and plan their writing. In this prewriting phase, the students often made lists of words or phrases to use as a reference when writing the first draft. When first drafts were written on paper, students usually worked individually; when they were composed at the computer, the students worked in pairs.

Most writing assignments on paper were assigned to improve writing fluency. For example, students were asked to write about personal experiences, to express feelings or wishes, to discuss topics like friendship, to describe objects, to share information and to give directions. Students spent some time each week in this type of writing. The papers were read by peers and then by the teacher. Some papers were collected and returned to the students with brief comments.

Some of the writing done on paper and most of the work composed on the computer was intended for audiences beyond the teacher. The "first drafts" of these papers went through several more steps of the writing process. They were often circulated to other students in small "response groups." Students read each other's writing and offered suggestions for improving the writing. Their suggestions focused on both the content and form of the papers. After the writers received the feedback from their peers, they were then given the

time to revise their drafts. This response and editing of papers replaced the more conventional "language" or grammar exercises traditionally used to teach writing mechanics. The final copies from this process were then displayed, published or sent to students in other classrooms. This final step, referred to as post writing, was as the teacher later wrote "the engine that drives the writing process" (Miller-Souviney & Souviney, 1985).

Writing assignments on the computer took more time to complete because all the students were required to cycle through the computer center twice, once for the first draft and a second time for the revision. Computer writing assignments took place in two week cycles; they included newspaper articles, computer-pal letter writing, poetry and narrative essays.

Newspaper writing was a central focus of the writing curriculum in this classroom and most of the students participated in the project regularly. All but 5 students wrote at least one article in one of the three newspapers they published. Each newspaper carried stories from about half the class. The stories for each edition of the newspaper were selected by students serving on editorial boards. The role of the editorial board was to read and evaluate all articles written for the current issue of the classroom newspaper. They were also responsible for final editing layout of the newspaper.

To serve on an editorial board students had to volunteer to give up some of their free time to accomplish the work. About 2/3 of the class was interested in assuming this role; 4 to 5 students were randomly selected from volunteers to edit each edition of the newspaper. About half the students

served on one of the three editorial boards.

Length of Essays in BMS's Classroom

The length of the students writing on paper and on the computer increased gradually and steadily over the course of the year. Table 5 shows the length of the different writing assignments at selected time points across the school year.

Pet Desc.	Sep (pretest)	Jun (posttest)
Mean:	X=48 (n=25)	X=106 (n=25)
SD:	(35)	(64)
Event Desc.	Sep (pretest)	Jun (posttest)
Mean:	X=65 (n=22)	X=84 (n=22)
SD	(33)	(61)

Classroom essays	Sep-Dec	Jan-Mar	Apr-Jun
Mean:	X=42 n=65	X=60 n=66	X=78 n=59
SD	(23)	(30)	(58)

Newspaper articles	Feb	Mar	June
Mean:	X=53	X=66	X=80
SD	(18)	(49)	(52)
	n=14	n=14	n=10

Table 5: The mean length of three types of writing assignments from September to June in BMS's Classroom.

Length of Writing Tests. The pre- and posttest writing assignments required students to describe a pet and a school event (see Appendix). They wrote on paper with no time limits. The same assignment was given at the beginning and end of the year, with 25 students available for the pre and posttest description of a pet, and 22 students available for both tests for description of an event. The mean length of the students' pretest essays were 48 and 65 words, and the mean length of the posttest essays was 106 and

84 words. There was a much greater increase in the length of the students' descriptions of their pets. However, individual variance is high. The median score on the description of a pet was 35 words for the pretest and 71 words for the posttest. The median for the description of the event was 54 words for the pretest and 72 words for the posttest.

Length of Classroom Writing Assignments. The classroom assignments represent a cross section of students' written work (on paper) which was collected by the teacher according to procedures previously explained. Each score represents the averaged length of papers written during the three month periods of Sep-Dec, Jan-Mar, and Apr-Jun. All students' papers for each topic were used resulting in slight differences in the number of papers in each period. Although there is a large range of individual differences, there is a steady increase in the means from 42 to 60 to 78 words.

The following essay is an example of a student's work at the beginning of the year. The assignment was to write an essay about "what you like to do on Saturday." The teacher lead a whole group "pre-writing" activity in which the students contributed ideas for essays. These ideas were listed on the blackboard and the students were then given time to write their essays. This essay is the same length (26 words) as the class average for this assignment. The spacing and errors are those of the student.

Denny Sept. 15, 1983

wach tv.
play go to the movies
skatboad play socer
ride my bike roller skat
play with my askshon figurs
go on a piknik whith my

In an essay at the end of the year, the students were asked to write about the meaning of the Olympics. The same pre-writing procedure preceded the writing of the essay. The essay written by this particular student is slightly longer (126 words) than the class average (105 words) for this assignment. Again it is typed as the student wrote it.

Denny Paul Johnson 6-7-84

The Olympic Dream

Being famous is't everything
as we learaned from Ted Duger
yesterday afternoon in Los Angeless
where they are holding the
Olimpics. Well now I don't know
weather you knew this or not but
Ted told me something that was
very interesting you have to
go through alot of pain. Now
alot of people think that the
Olympic dream is to be fanous
but it really is't the Olympic
dream is to compeat and to
have fun doing it.

Now I would like to tell
you a story when I was a
kid the Olympics were being
held in L.A. we were having
an Olympics at are school I
never won but I had fun
doing it so it didn't matter.
Of course thats the Olimpic
dream to me.

The first essay was similar in length (as well as quality) to ones written by other classmates. This student provides no introduction to the essay and handed in the essay without completing the last idea. Except for the first period, there is no punctuation. It is an almost telegraphic message to the teacher which simply provides the minimal information necessary to answer the question that she posed: What do you do on Saturday?

The second essay has both an opening sentence and a final concluding sentence. While the student still makes both spelling and punctuation errors, there is much improvement over the earlier essay. He is able to express his ideas about the Olympics in a coherent way with only a slight problem with the time frame from the first to the last paragraph. These essays provide an example of the average increase in the ability of the students to express their ideas in writing over the year.

Length of Newspaper Articles. There were three editions of the Computer Chronicles Newspaper published in this classroom (Table 6). The stories in these newspapers are the results of pairs of students composing articles at the computer. The newspaper represent the students' selection of the best articles written by themselves and the other newswire reporters.

Newspaper edition dates:	Dec	Mar	June
Total number of stories:	25	35	18
Total in paragraph format:	19	30	17
Newswire stories (paragraph):	5	16	7
Local stories (paragraph):	14	14	10

Table 6: The number of stories in each of the editions of the newspapers that were in a format in which length was assessed.

The three editions of the newspapers contained 21, 35, and 18 articles respectively. A slightly smaller number had the appropriate form for a word count (19, 30 and 17). For the first edition, most of the stories were written by the students in the classroom, but the second and final editions carried a higher percent of stories that were written by other students and received on the newswire.

Notice that the length of these computer generated articles (Table 5) were about the same as the length of essays written on paper at roughly the same period. This means that the students who wrote these stories had mastered the technology of the computer sufficiently to write essays that were of similar length to those that the class wrote on paper.

Summary of Length of Essays. Examining the length of the students essays in this class over the year indicates a steady gain in the length of students' writing. Looking across the three types of writing assignments, the students essays at the beginning of the year were an average length of about 50 words. At the end of the year the students work was more likely to be about 80 words in length. This indicates an increase of approximately 30 words or 60% in the length of writing over the year.

Quality of Essays in BMS's Fourth Grade

The quality of students' pre and post test essays was scored using the holistic scoring procedures described in Grubb (1981); the other writing samples were scored using the modified holistic scoring procedure described earlier. The essays were scored on a 0 to 4 point scale (see Appendix) and the results are displayed in Table 7. Overall, it indicates steady improvement in the quality of students' work over the year.

Pet Desc.	Sep (pretest)	Jun (Posttest)
Mean:	X=2.00 (n=25)	X=2.32 (n=25)
SD:	(.79)	(.80)
Event Desc.	Sep (pretest)	Jun (posttest)
Mean:	X=1.86 (n=22)	X=2.54 (n=22)
SD	(.80)	(.94)

Classroom essays	Sep-Dec	Jan-Mar	Apr-Jun
Mean:	X=2.09 n=65	X=2.15 n=66	X=2.47 n=59
SD	(.70)	(.81)	(.75)

Newspaper articles	Feb	Mar	June
Mean:	X=2.58 n=14	X=2.64 n=14	X=3.10 n=10
SD	(.79)	(.84)	(.74)

Table 7: The mean holistic scores (0-4 point scale) for three types of writing tasks in BMS's fourth grade classroom.

Quality of Writing tests. In comparing the improvement on the pre and posttest essays, the students improved more on the description of an event (1.86 to 2.54) than they did on the description of the pet (2.00 to 2.32).

The following pair of essays is an example of the gain in the quality of student writing from pre- to posttest.

Carol B_____'s description of an event pretest:

10/13/83

The Field Trip

One day last year in Mrs. Burts class we went on a field trip we went to Cedar Lane Park. We played kickball and had a snack. People were running around laughing and playing. Mrs. Lockharts class and Mrs. Grahms class came to. Some people had to stay in the classroom because they didn't bring their permision slip back. Well we stayed there for 2 hours then we went back to the school right before lunch recess. Everyone who stayed at the class asked did you have a good time? We told them of course we did.

The End

Carol B_____'s description of an event posttest:

6/4/84

Balloon Liftoff

Here at Olive School for our first time we had a balloon Liftoff. They held it on Jan. 13 1984. It was beautiful. First before we started they sent heilium balloons to each and every class room. And when our class room "B-2" got their balloons we went to to field and sat down. Then we attached cards that had Olive School's adress on it. And we had to write a little note asking them to send this card and write were you live and you can write a little note please. And the they blew a whistle and we let all our balloons in the air it was so beautiful seeing all those colors. Some were bleu, some were green there were all kinds of beutiful colors. Weeks later we had open house and they announced the kids who got their card back. And some of the balloons went to Washington, New Mexico, and all other kinds of places. And they announced the winners for the balloons that went the farsest the winning people were, Kevin Dunne his went to Riverside and Thereasa Caywood hers went to New Mexico.

it was neat....

The End

Both essays were scored high relative to the rest of the class, however the difference between them is representative of many of the other sets. The first essay was scored as 3 and the second as 4 by all of the readers.

In the first essay Carol begins weakly with "One day last year" and finally gets to the topic of the sentence, and the essay, at the end of the poorly formed sentence. The topic "is a good response to the prompt" but was not "completely clear throughout the composition." After a few details of the picnic, she indicates who went on the picnic with a side sequence about students who were unable to go on the field trip. This discussion is an example of the "irrelevant story or explanation" that are sometimes present in stories that were scored 3. The story is clearly about a field trip and with the exception of these comments, the topic is carried through to the end. There was appropriate word choice, though "not particularly vivid" and

there were "sufficient details to make the description clear." While the story could have been better written, the sentence structure problems and grammar errors were not numerous. Ending with a quote and the reply to it was a nice touch.

The second essay is, in some ways, similar to the first. It begins by introducing the event in time and space and ends with her evaluation of the event, "it was neat!". However in this essay the information is presented in much better detail and sequence. It has "a clear topic which is an appropriate response to the prompt and which is introduced at the beginning of the description" with "good organization, including an introduction and a conclusion." The description of the whistle blowing and the colors of the balloons are examples of the "sensory details" in the story. There may be some confusion of facts in the story. If "Washington" meant the state of Washington and Riverside referred to a community in California, then it is hard to see why one of the winners was Riverside. However, the story was easily scored as 4 using the grading rubric (Appendix).

Quality of Writing Assignments. The classroom writing assignments represent a range of different types of writing tasks. Despite the diversity, the quality of classroom work on paper shows a pattern of improvement that is similar to that of the pre- and post testing. The average score of 2.09 for the first period (Sep-Dec) is similar to the 2.00 scored on the description of a pet, and slightly higher than the 1.86 scored on the description of an event pre test. Similarly, the class average (2.47) on the writing assignments for the last period (Apr-Jun) is slightly lower than the scores for either posttest (2.32 and 2.54) given in June.

Quality of Newspaper Articles. The newspaper articles also improved in quality over the year at a similar rate. Each issue contained articles from different students or pairs of students on different topics. There is, however, one pair of articles from the beginning of the year that contain similar content and have one author in common. The mistakes are those made by the authors.

Article by Sharon B___ and Tim D__ for first edition of Computer Chronicles:

Olives Crazy Day

Olive school had a crazy dress-up day.
We had it at Olive school on 11-23-83.
We had it because people did not receive
gold slips.
People dress up crazy.

By Sharon B____, age 8 and Tim
D_____, Age 9

Article by Sharon B____ for the last edition of the Computer Chronicles:

The Egg Drop

On April 13, 1984 the fourth and fifth graders at Olive School had an Egg Drop. We did it to see how creative we could be. You could use anything not over 12 inches long, and you put a raw egg in it with any sort of padding. Then the teachers from the school threw it down from a classroom building and if your egg didn't break you got a treat!

By Sharon B____, age 9

There seems to be an attempt in both article to include information in response to the computer prompt to describe what happened, to whom, when, where and why. The first essay was given a holistic score of 2, the second one was scored as 4.

The essay written at the beginning of the year about Crazy Day has "a topic that is an adequate response to the prompt" in this case to write about something that happened at school, but there is "minimal development of the description" with "few details and "unclear organization". Sharon makes the assumptions that the reader will know what gold slips are and why they are given. Without this information, it is very difficult to understand the story.

In the second story, the writer was more successful at including the necessary details to make it possible for students from other schools to understand what took place. The essay has "a clear development of the description, with no irrelevant stories or explanations," with "specific, vivid word choice," and "good organization."

Over the year students had frequent discussions in editorial board meetings about what "students in Alaska" would or would not understand. They became increasingly more skilled at providing information that they had taken for granted when writing for the teacher or for a local audience.

Summary of Quality of Students' Writing. The quality of the students' writing in this classroom show steady increases over the year. The greatest improvement is in writing newspaper stories. The students rate of gain from the pre- to posttest description of an event (36%) represents the highest rate of change. The published newspaper stories written on the computer show the next highest gain (20%) followed by the gain on classroom assignments (18%) and the pre/posttest description of a pet (16%).

This ranking suggests that the functional writing environment created by the Computer Chronicle Newswire did have a positive influence on the students' writing ability. While we do not have a matched control classroom to compare this rate of improvement, standardized testing provides some evidence that the gains made by these students were much greater than what is expected in the one year period.

Standardized Tests of Language and Reading Skills

As mentioned earlier, the California Test of Basic Skills (CTBS) was given at the end of each school year. The results of this testing are shown in Table 8.

LANGUAGE	1983	1984	READING	1983	1984
Spelling			Vocabulary		
Grade level eq.	3.9	5.1	Grade level eq.	3.9	5.1
SD	(2.2)	(2.0)	SD	(3.8)	(1.4)
Mechanics			Comprehension		
Grade level eq.	4.0	6.9	Grade level eq.	3.9	5.8
SD	(1.6)	(2.5)	SD	(1.5)	(1.8)
Expression					
Grade level eq.	4.1	5.9			
SD	(1.4)	(2.6)			
TOTAL			TOTAL		
Grade level eq.	3.9	5.7	Grade level eq.	3.9	5.4
SD	(1.4)	(2.1)	SD	(1.2)	(1.5)

Table 8: The results of the California Test of Basic Skills (CTBS) standardized testing for BMS's fourth grade classroom (n=22), expressed in grade level equivalents, at the end of third grade (1983) and fourth grade (1984).

The scores in May 1983 indicate that the students were, on the average at grade level (expected 3.9) in almost all areas. When tested in May 1984,

however, they were above average in all subtests of writing and reading. The students show the highest gain in language mechanics (2.9 years) with high gains in the language expression (1.8 years) and reading comprehension (1.9 years) scores.

The dramatic increase of almost three years in language mechanics and almost two years in language expression and reading comprehension suggests that the functional learning environment created in this classroom was successful in teaching language art skills. Language mechanics taught in the context of students' writing and the process of peer review appears to be very effective strategies for helping students learn to write. Reading stories written by their peers in distant locations, as well as reading to interact with the computer, seem to have had a favorable effect on their reading ability as measured by this achievement test. The overall gains in the Language skills are represented in Figure 12.

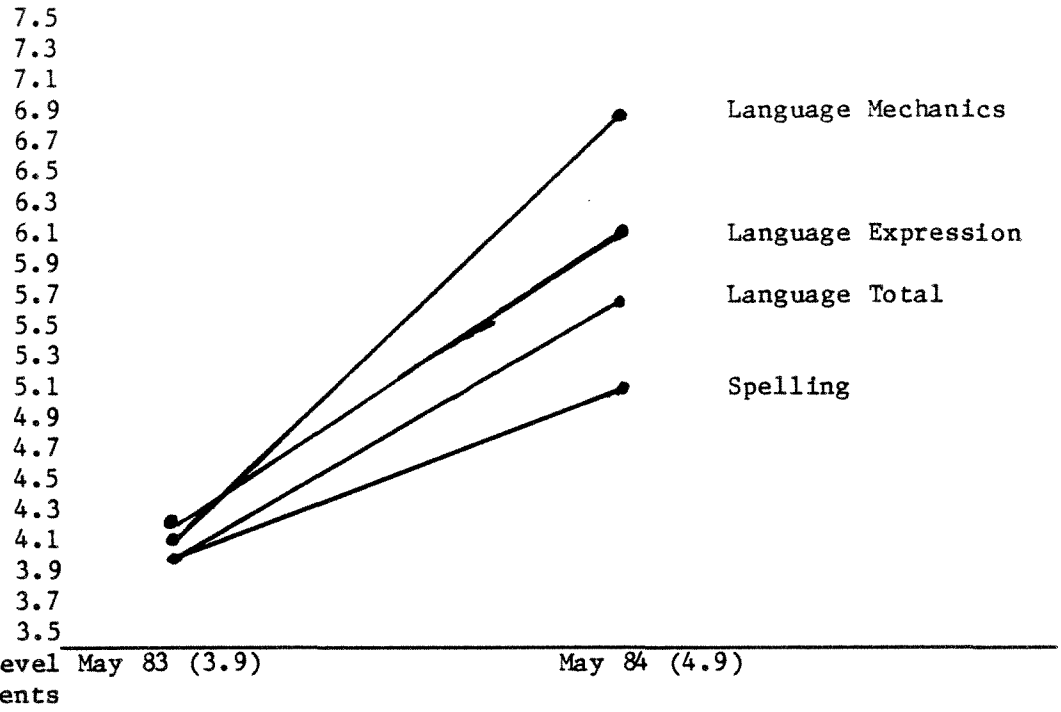


Figure 12: Comparison of grade level equivalent scores on the language portion of the California Test of Basic Skills at two times, May 1983 and May 1984 for the students (n=22) in BMS's fourth grade classroom.

Past research has pointed to the effectiveness of teaching language mechanics in the context of student writing rather than in grammar exercises (Strom, 1960). However in this classrooms students were editing the work of their peers as well as receiving feedback on their own writing. The following comparison suggests that editing the writing of other students may be one of the crucial factors that leads to improved writing skills.

While most of the students in this classroom wrote stories for a newspaper and national news network, a smaller number of students participated in "editorial boards" described earlier. These students were exposed to a wide range of writing skills and language problems. Collectively they formed evaluative frameworks which could then serve to guide their own writing.

If serving on an editorial board was a vital part of the learning experience that lead to the improvement in the language art skills, then we would expect the students who served on an editorial board to score higher then the class average who did not have this experience. The students selected for the first board should show the greatest gains since they had the longest period after this experience to improve their writing. The students serving on the first editorial board were selected randomly from the 2/3 of the students who volunteered for this position.

Table 9 shows that in May of 83 the scores of the four students who made up the first editorial board were very similar to the class means in the language portion of the CTBS with the exception of a slightly higher score for language expression.

	1983	1984		1983	1984
Spelling			Mechanics		
Class Mean (n=22)	3.8	5.1	Class Mean	3.9	6.8
SD	(2.2)	(2.0)	SD	(1.6)	(2.5)
Edit. Board (n=4)	3.8	5.0	Edit. Board	3.9	8.6
SD	(0.7)	(0.6)	SD	(1.4)	(1.2)
Expression			Language TOTAL		
Class Mean (n=22)	4.1	5.9	Class Mean	3.9	5.7
SD	(1.4)	(2.6)	SD	(1.4	(2.1)
Edit. Board (n=4)	5.1	6.3	Editorial Board	4.1	6.1
n=4	(1.7)	(1.4) n=4	SD	(0.7	(0.8)

Table 9: Comparison of test scores on the California Test of Basic Skills for the fourth grade class with the members of the first Computer Chronicles editorial board.

Again the difference that is striking is the increase in language mechanics.

The students gained over 4 grade levels in this area. Figure 12 shows the gain for these students from September to June.

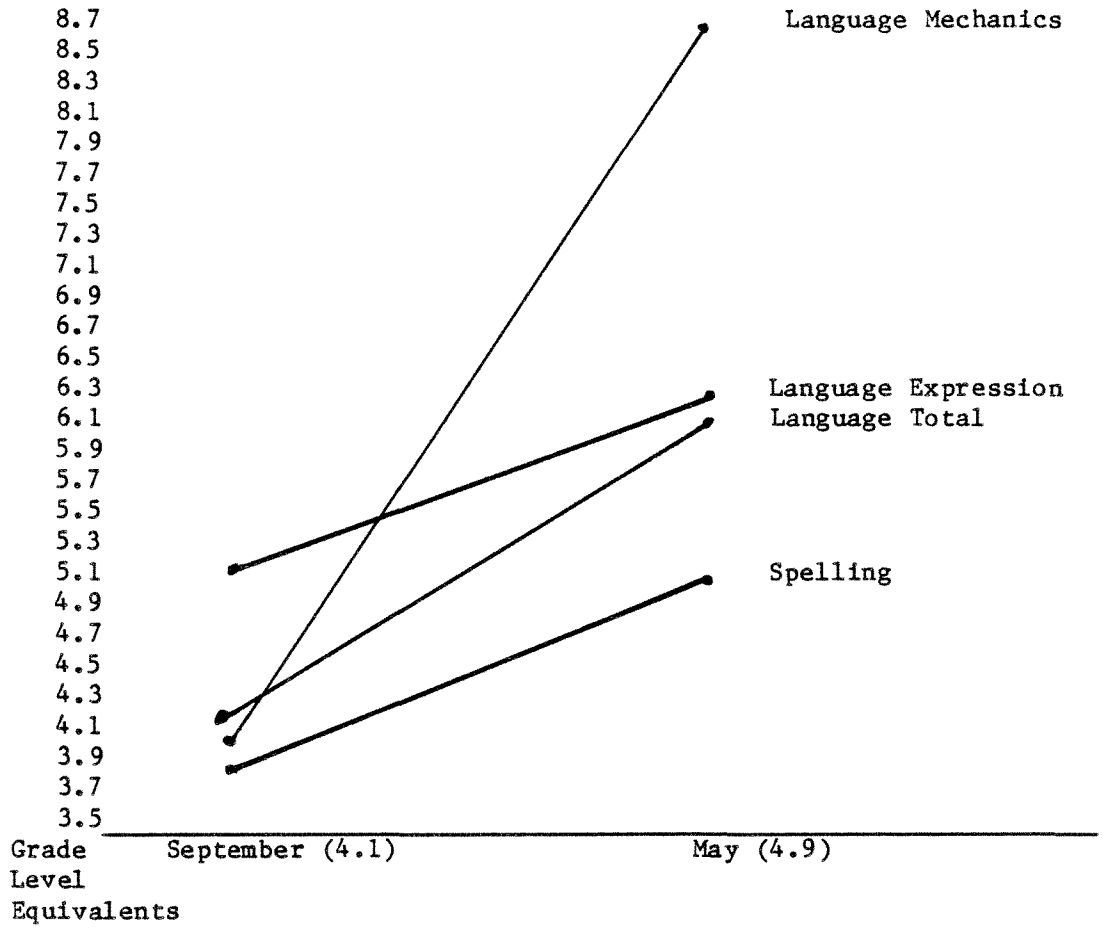


Figure 13: Comparison of grade level equivalent scores on the language portion of the California Test of Basic Skills at two times, May 1983 and May 1984 for the students (n=4) randomly selected to be members of the first editorial board in BMS's fourth grade classroom.

Figure 13 is very similar to figure one with the exception that the language mechanics shows an increase of 4.5 grade levels. This finding suggests that it is not only the correction of one's own errors in the context of writing, but perhaps even more important, the evaluation of the

writing of others that leads to gains in the mechanics of writing. The process of peer review may be a valuable resource for helping students learn to write.

Conclusion

Standardized and project testing and classroom work all point to the same conclusion. The students in this fourth grade classroom learned a great deal about language as an art. They were able to master the use of a new form of technology for writing and do so while improving their writing and reading skills beyond their grade level expectation. The evidence from this classroom indicates that a skilled language arts teacher with some prior computer experience can use the computer to create functional learning environments for students that are very effective for teaching language arts skills to fourth grade students.

In the other project classrooms, some but not all of these features were present. In the following classrooms, the focus will be on the how the presence or absence of some of these features resulted in similar or different patterns. Each of the classrooms provides another perspective on the way computers can be integrated into the learning process.

Description of Writing in KW's Fifth-sixth Grade

KW and BMS shared a similar educational history which is reflected in the organization of their classrooms, general teaching strategies (chapter

two) and approaches for teaching writing. Most of KW's teaching experience had been in upper elementary grades, however this was her first experience teaching a "GATE" (Gifted and Talented Education) classroom.

KW had minimal knowledge of computers prior to the project. She had taken some courses designed to help teachers review software, but had little experience using a computer and described herself as somewhat computer phobic. The software that was used on the project was new to her and she learned how to use it her students.

KW encouraged her students to try to work independently and to try to solve their problems themselves. If that failed designated "peer computer experts" were to serve as resources. KW used the same strategy in developing her own computer skills. She explored a number of possible solutions to a problem and then, if unsuccessful, she called on member of the research staff for advice. She once refused a researcher's offer to solve a software problem, arguing that teachers do not routinely have that type of support. She chose to delay the introduction of the new software until she was able to make the necessary changes herself.

KW and BMS taught writing as a process in much the same way except that in KW's classroom the whole class was less likely to participate in the pre-writing phase as a whole group. Instead, students were encouraged to individually generate ideas, organize them and plan their essays prior to writing. Students were required to write often with increasing length requirements to encourage writing fluency.

The initial computer activities were directed toward helping students

master the hardware and software procedures. The major writing activity at the computer center was composing newspaper articles. Beginning in January, the students wrote or edited newspaper stories for 3 weeks. Then, while an editorial board assumed the task of evaluating and assembling the newspaper, the rest of the students worked on some other writing task on the computer, including computer-pal letters and a variety of interactive reading and writing programs.

All students in this classroom wrote one or more articles for the class newspaper; each of the four editions of the newspaper carried articles from over half the class. Most the students had the opportunity to serve on an editorial board. Members of the editorial boards for each edition were selected from those that wanted to participate (over 3/4 of the class) by KW. She made the selections to ensure even numbers of boys and girls, of 5th and 6th graders and a mix of skill levels.

Length of Student's Writing

The length of pre and posttest essays, classroom assignments and computer newspaper stories are displayed in Table 10.

Pet Desc.	Sep (pretest)	Jun (Posttest)
Mean:	X=74 (n=23)	X=108 (n=23)
SD:	(31)	(44)

Event Desc.	Sep (pretest)	Jun (posttest)
Mean:	X=71 (n=25)	X=91 (n=25)
SD	(25)	(32)

Classroom essays	Sep-Dec	Jan-Mar	Apr-Jun
Mean:	X=95 n=83	X=179 n=60	X=207 n=121
SD	(38)	(63)	(59)

Newspaper articles	Feb	Mar	June	
Mean:	X=104	X=64	X=91	X=82
SD	(37)	(29)	(39)	(27)
	n=21	n=16	n=9	n=13

Table 10: The mean length of three types of writing assignments from September to June in KW's classroom.

Length of Writing Tests. There were 23 students who were available for both the pre and posttest descriptions of pets and 25 for the description of a school event. The pretest scores indicate that the length of students' essays were, on the average, about 74 words when describing a pet and 74 words when describing an event. At the end of the year the students' essays were 108 words for the pet description and 91 words for the event description. The increase in the length of the essays is very similar to the pattern in BMS's classroom.

Length of Classroom Writing Assignments. Writing assignments were collected from the students at the beginning of the year, at roughly monthly intervals and at the end of the year. Table 10 shows the average length of these different sets of papers. The increase in the length of students' writing in this classroom was influenced by the teacher's minimal length requirements. The teacher set a higher standard as time went on "to encourage both fluency and extension of expression," to "stretch" their writing

skills. The teacher began to set minimum length in November at 125 words and increased the requirement by 25 words about every 6 weeks. At the end of the year the minimum was set at 250 words. While the students did not all meet this requirement, this strategy did seem to be effective in increasing the length of the students' writing. It will be important to see if this increase in length was accompanied by an increase in the quality of their writing.

Length of Newspaper Articles. The teacher had planned to publish a monthly newspaper each month beginning in January. It took the editorial boards longer to make their decisions and edit the stories then she originally expected, however, and a total of four were produced, one in February, one in March, and two in June. The increasing number of stories received over the newswire from other classrooms extended the editorial board's deliberations for the last two editorial boards to the end of the year; the number of newswire stories accepted increased dramatically (see Table 11).

Newspaper edition dates:	Feb	Mar	June	June
Total number of stories:	27	31	24	53
Total in paragraph format:	22	20	20	50
Newswire stories (paragraph):	1	4	11	37
Local stories (paragraph):	21	16	9	13

Table 11: The number of stories in each of the editions of the newspapers that were in a format in which length was assessed.

The mean length of the stories on the first edition of the newspaper (105 words) was longer than that of any of following editions. Almost all of the stories in the first edition were not composed at the computer. These

stories were written by individual students on paper before they learned how to use the software. They were typed into the computer as an early exercise in learning how to use the computer. The stories for the second edition were composed at the keyboard by pairs of students and the mean length of these stories dropped to 64 words, which is lower than the mean of students' individual writing off the computer. The articles in the last two editions of the newspaper (91 and 82 words) show a rate of increase that is similar to the articles produced in BMS's class.

The mean length of these articles is only slightly less than the mean length of the newspaper articles written on paper with pencil at the end of the year (91 words). This comparison indicates that the students who wrote these newspaper articles were able to compose articles on the computer and within the social and time constraints of the computer sessions that were similar in length to the posttest stories written on paper individually with no time limits. In doing so, they demonstrated their ability to master a new writing technology and to develop collaborative writing strategies at the same time as learning to extend the length of their writing on a given topic.

Summary of Length of Student's Essays. The students in KW's class show steady pattern of increase in the length of their writing across the year. The increase in the length of classroom essays written on paper were clearly influenced by the minimum length requirements established by KW. The similarity between the lengths of the posttest news essays written on paper and the newspaper articles at the end of the year composed on the computer suggests that the students were able use the computer effectively for their writing.

Quality of Writing in KW's Classroom

The pre- and posttest essays quality measures of classroom assignments and computer newspaper stories are displayed in Table 13. Assessing improvement in the quality of writing in this classroom is made more difficult by a ceiling effect in most of the measures.

Pet Desc.	Sep (pretest)			Jun (Posttest)
Mean:	X=3.05 (n=23)			X=3.20 (n=23)
SD:	(.66)			(.68)
Event Desc.	Sep (pretest)			Jun (posttest)
Mean:	X=2.40 (n=25)			X=3.43 (n=25)
SD	(1.27)			(.60)
Classroom essays	Sep-Dec	Jan-Mar	Apr-Jun	
Mean:	X=2.70 n=83	X=3.41 n=60	X=3.47 n=121	
SD	(.92)	(.69)	(.63)	

Newspaper articles	Feb	Mar	Jun	Jun
Mean:	X=3.42	X=3.66	X=3.12	X=3.42
SD	(.51)	(.62)	(.64)	(.67)
	n=9	n=16	n=9	n=13

Table 12: The mean holistic scores (0-4 point scale) for three types of writing assignments from September to June in KW's classroom.

Quality of Writing Tests. The students in this classrooms, like those in the other project classrooms, wrote better essays at the beginning of the year about a pet rather than a school event. The lower initial scores in the description of an event suggest that students were not as skilled in this type of writing task. There was, however, more improvement in the students' description of a school event at the end of the year than in the pet descriptions. The students' participation in the newspaper writing

activities is likely to be partially responsible for the difference but there is also likely to be a ceiling effect of the initially higher pretest scores for the description of a pet pretest.

The following set of papers is an example of one student's pre and posttest descriptions of a pet that scored lower than the class average. The pretest was a description of a horse and was written like this:

Mary

I got a pet to today it's a horse.
it's white all over and it's a stallion.
and it wineis. and it feels like silk
and velvit. I think all ride all
over the country.

The posttest for this student is a description of a unicorn. (Some students asked,and were given permission to describe an imaginary animal by KW). This is how the second essay looked:

Mary H _____

My Pet

My mom got me a pet
today. it is a unicorn. he is real
big, it is so big that it is
nine feet tall (on four legs). he
is pure white except for its
horn. it is pure gold. it is a
beutiful unicorn. my unicorn
snorts and grumbles and sometimes
purrs or wines. he feels like
silk or velvet. My pet looks
manifucent after he is brushed
and his hair is washed. his name
is Maltia Mikea. he is a
beutiful animal.

the end.

The pretest for this students received a holistic score of 2 by the three readers. This indicates an adequate essay. It has "a topic which is

an adequate response to the prompt" yet it has "minimal development of the description" with "few details." There are "many errors in the use of punctuation marks, capital letters, and spelling" and "incorrect or inappropriate structure in many sentences."

The posttest essay shows clear improvement over the pretest. It has "a topic which is a good response to the prompt" and has "good organization." While it has "specific, vivid word choice" and a brief "introduction and conclusion," features of an excellent essay (4 points), it also has "many errors in the use of punctuation marks, capitals letters, and spelling" and "incorrect structure in many sentences," features of a adequate response (2 points). Since most of the characteristics fall in the category of a good composition (3 points) with some falling in the excellent (4 points) and some in an adequate category, the holistic score given by the three readers was 3.

Both the pre and posttest scores of this student were below the class norm, with a higher rate of improvement. The average student pretest was similar in quality to this second essay. While in most cases there was improvement in some features of the description, they were often not sufficient for it to be scored as an excellent essay. The use of a six or eight point scale rubric would have been necessary to show these changes.

Quality of Classroom Writing Assignments. The students classroom work shows a steady improvement in quality over the year. During the first the months, the average holistic score of the essays was 2.70, during the second period it increased to 3.41 and during the last period it was 3.47. Again

there is likely to be a ceiling effect for the gain in the last period. What is of particular importance is that the gains in length that were pushed by minimal length requirements were accompanied by corresponding increases in the quality of students writing.

The following two stories by one students indicate the average gain in quality from the beginning of the year to the end of the year. Both stories are "stickers stories", stories that are inspired by the illustrations on stickers that students select.

Sticker story, October 5, : Sticker shows three brightly colored helium ballons

The Rainbow Ballons

One Day I won 3 helimun Ballons I was so excited. I asked my friends, Collem and Monica if they would like to ride in one each. The both said Yes and I said to bring a friend. I decied to ask my best friend Tiva to ride with me.

The next day I packed three big lunches. My friends arrived at noon. First came Collen. "This is my friend Vivian." She said. Then Monica "I would like you to meet Brandy." They each brought "an animal. Collem broght a monkey named krakers. Monica brought her cat named Sugar Pie. I had my Dog named Bets.

I let Monica and Brandy have the have the red one. Collem wanted the Blue one. So I got the green and yellow one. We stared off at one o´clock We floted around for along time. Everyone on the ground called us the Rainbow Ballons. Finnally we landed at 5´o´clock. My friends said it was fun. That´s the story of the Rainbow Ballons.

Sticker story, April 8, : Four stickers, one of blond woman, a rose, a butterfly and a unicorn in front of a rainbow looking into a blue pond with blue clouds.

BLUE MIST

By Robin T_____

There once was a young princess who had a very large imagination. The funny thing was that whatever she imagined came true. One day she was sitting in her rose garden. (She loved roses.) She started imageing a unicorn drinking from a crstal clear pond and behind the unicorn there was rainbow. Then a voice started calling her. She looked up and saw a butterfly. "Ivinnia! Ivinnia!!" it said. "Oh, sorry." She said. "It is just I always get involved in my day dreams. I always wonder were it is going to show up! "Ivinnia," the butterfly said "they are going to disappear. That is all of them except 3." "What do you mean?" asked the startled girl. "I mean your time is up." replied the butterfly. "So what 3 is it going to be?" She just sat there thinking for a minute. "I have a question." said Ivinnia. "Can I have a new one?" "Sure." Said the butterfly. "Only if you have a good reason." "Well began Ivinnia "My first wish is I want a rose. The most beautiful rose in the universe. I also want you to keep me company." "Your wishes are my command." he said. "And last but least" said Ivinnia "I want the unicorn picture. "Follow me!" said the butterfly and she did. While she walked everything started disapering. At the end of the path there her wishes were. She started running. Her heart was filled with joy. All around her there was a blue mist. She ran, picked up the flower and jumped on the unicorn. Calling the butterfly she took off into the blue mist. She ended up calling the unicorn blue mist.

The first story was scored as a good composition according to a four point rubric for narrative writing (see Appendix). It has a "sequence of events which is a good response to the writing prompt" in this case the picture. While there is "good development of the story" it is "marred by an irrelevant description" of the pets that were taken in the balloons. There is a clear temporal "organization of the story" and "good word choice, which

is, however not particularly fresh or vivid" and includes "some errors in the use of punctuation marks...and spelling".

The second essay indicates real development in the students' control of a number of narrative conventions. It was scored as an excellent composition according the the four point rubric for narrative writing. Its strong features are a "fresh and vigorous word choice," "a variety of interesting details," and a "clear sequence of events which is an appropriate response to the prompt and is introduced at the beginning of the composition." It has correct and appropriate structure in almost all sentences" and very few errors "in the use of punctuation marks, capital letters, and spelling."

The first essay is very similar in quality to those written by the other students in the class. The increase in quality between this early essay and one written in April is similar to that of many of the other students in the classroom. The quality of students' work in this classroom increased dramatically between the first and second periods and then, possible because of individual differences and a ceiling effect, the rate of increase becomes much more gradual.

Quality of Newspaper Articles. The stories accepted for the newspaper began at a relatively high level of quality with small changes across the issues. It is likely that this pattern is the result of a ceiling effect. The mean score for the articles in each issue were: first issue 3.42 (n=22), second issue 3.66 (n=16), third issue 3.12 (n=9) and final issue 3.42 (n=12).

The stories for the first edition were composed on paper and typed into

the computer. The stories for the second edition were composed on the computer by pairs of students writing together. They were, on the average, shorter (64 words) than any other of the writing samples written either on or off the the computer. They are also, on the average, better written (3.66 points) than any of the writing samples.

During this time, KW noticed that students' collaborative essays on the computer were much shorter than essays written by students working alone off the computer. She also noticed that the students working together at the computer were spending time discussing their writing. She suspected that the students were spending more time editing and revising their work and that the shorter length might be offset by higher quality of the writing. (Papers had not been scored at this point).

Interested in the effect of collaborative writing on length and quality of essays, she assigned pairs of students the task of cooperatively writing a newspaper story using a single sheet of paper to compare with the stories pairs of students wrote using the computer writing tools. Unfortunately, the same pairs of students were not assigned to each of the conditions. Therefore, we compared the length and quality of the cooperative stories written on paper (n=14 essays) with a set of newspaper articles written by pairs of students working on the computer during the same week (n=9).

There was no difference in length between the two sets of papers. The mean length for stories written collaboratively on paper was 81 words, and the mean length of stories written collaboratively on the computer was 80 words. The quality of the paper/pencil was similar to the computer sample;

the holistic score was 3.7 for paper/pen essays and 3.6 for computer essays . No writing sample on paper was scored higher than 3.7 and the average writing sample for this time of year was 3.5.

Students' collaborative essays either written on paper or on the computer were shorter but of higher quality than individual essays. Students seem to be doing more than composing a first draft when they write collaboratively. The immediate feedback from the other person helped clarify ideas as essays were being written, resulting in more revising and editing than when they worked alone. This suggests collaborative writing that is facilitated by the computer may be a important factor in the gains in quality of writing that were evident in these classrooms over the school year. Collaborative work, facilitated by the computer, may be an important way to maximize students' learning.

Summary of Quality of Writing. Writing pre- and posttests show a dramatic increase in the quality of students descriptions of events. The higher scores on the pretest description of pets suggests a ceiling effect. There was a steady increase in quality of the students classroom assignments that parallels the increases in length. The cooperative writing of newspaper articles at the computer resulted in shorter articles of higher quality. It is likely the collaborative writing is one of the important dimensions responsible for the increases in the quality of student work over the year.

Standardized Tests of Basic Skills. In this fifth-sixth classroom, only the fifth graders were given the California Test of Basic Skills at the end of the year. About a third (6 of 17) of the fifth graders had reached

the test score ceiling (10.9) at the beginning of the year. Another 4 reached the ceiling some time during the year. The 7 remaining students ranged from one student that showed no change to a student with a gain of three years. The small number of students and the large variation makes it impossible to use standardized testing as an indication of student gain in this classroom.

Conclusion. The teacher in this classroom, KW, was experienced in teaching writing but was a novice in terms of computer use. She was working with upper-grade talented students. She had little difficulty in extending her teaching strategies to include the computer as one of many work stations in her classroom. The students were able to use the computer tools to extend their writing skills. It was difficult to assess the increase of students skills in this classroom because of a strong ceiling effect. This effect was evident in the project testing, evaluation of student's writing and in standardized testing by the school district. Even with the ceiling effect, the students in this classroom showed gains in writing that were similar to those of the students in BMS's classroom. The role of peer review in collaborative writing was again pointed to as the one of the significant aspects responsible for improvement in writing skills.

Description of Writing in BL's Third-fourth Grade

BL is a bilingual teacher with previous experience in teaching upper grade students. This was her first teaching experience with younger students. Prior to the study, she had no special training in the area of language arts instruction, minimal experience with computers and was

unfamiliar with the software used on the project.

BL's school had a rotation procedure which regrouped students homogeneously according to skill level for math and reading. In this arrangement, the third and fourth grade students with the lowest achievement scores in reading were grouped in her classroom for language arts. This group also included a large number of Limited English Proficient (LEP) students. The students in BL's classroom for reading and writing were reading at the first or second grade level in either Spanish or English as measured by the California Test of Basic Skills.

At the beginning of the year there was no printer in BL's classroom. The students saved their stories on disk to be printed out later using a printer located in another classroom. In mid-January a printer was provided for the classroom.

As in the other classrooms, the first computer activities (Typing Tutor and Apple Presents Apple) were designed to give the students some familiarity with the keyboard. The students then worked with some interactive story programs that helped the students make their own stories without having to write text. In November the students were introduced to writing Computer Chronicle stories with a choice of working in either English or Spanish. The students with low reading levels had trouble understanding the writing instructions and some found the task too difficult.

BL decided to switch to interactive programs that required less writing by the students while she explored ways to provide social support for writing on the computer. In February the students resumed writing newspaper articles

along with the other computer activities with the help of peer tutors or bilingual computer coaches. The teacher used a number of different interactive tools trying to find the necessary match between the skills of the students and the level of the programs. While students enjoyed many of these programs, BL wanted to be able to integrate the computer with other classroom activities.

As her own skill with the computer software increased, she decided to use the interactive system (ITI) to write her own activities. After a few hours of training, she wrote two computer programs to use with her students. One was a prompt to help students write friendly letters and the other was a book report form. In both cases she wrote English and Spanish versions. These computer activities were introduced in the last two months of school and were integrated with other activities that occurred in the classroom.

Length of Students' Essays in BL's Class

The length of students' essays over the year show a steady increase in length (Table 13). While these students began the year with skills that were much lower than the classrooms discussed so far, their rate of improvement is very similar to these other students.

Pet Desc.	Sep (pretest)		Jun (posttest)
Mean:	X=47 (n=15)		X=69 (n=15)
SD	(21)		(32)
Event Desc.	Sep (pretest)		Jun (posttest)
Mean:	X=59 (n=14)		X=71 (n=14)
SD:	(33)		(41)
Classroom essays	Sep-Dec	Jan-Mar	Apr-Jun
Mean:	X=38 n=24	X=45 n=33	X=68 n=21
SD	(20)	(24)	(28)
Newspaper articles			June
Mean:			X=52 n=32
SD			(28)

Table 13: The mean length of three types of writing assignments from September to June in BL's classroom.

Length of Writing Tests. Like the students from the other classrooms, the students in BL's classroom wrote slightly longer essays describing a school event than they did when describing an animal. The mean length of the posttest was almost the same for both of the topics. This means that the gain in length for the description of a pet was greater than that for an event, as it was for each of the previously discussed groups of students.

Length of Classroom Writing Assignments. The mean length reported for classroom essays for each of the three periods represents the work of the low achieving monolingual students. Most of the writing in this classroom was done during the period of the day in which students were grouped based on reading levels. Often the bilingual students who were in BL's classroom for this period worked with a bilingual aide on reading skills. Therefore, they were not present for many of the writing activities.

The average length of students' work in the first three months of school (38 words) was shorter than the average length of either of the pretests (47 and 59 words). The length of work during this first period was also only slightly shorter than that of the fourth graders in BMS's class for this same time period(42 words).

The pattern of gain in the length of essays over the year is different in this classroom than the previously described classrooms. In BMS's and KW's class the greatest gain was made between the first and the second trimester. In BL's classroom the increase in the length of students' writing is much greater between the second and third period than it was during the first and second. This early period is when BL had difficulty finding appropriate computer activities for her students. The low reading level and the special need for bilingual software slowed down the integration of the computer in this classroom. It was not until the latter part of the year that the students in BL's classroom were using the writing tools productively. It is possible that the students longer essays in the later part of the year were influenced by more successful writing experiences on the computer.

One way to assess the gains made by these students at the end of the year is to compare the length of their essays written at the end of the year to the older students essays written at the beginning of the year. The posttests of the low achieving third-fourth graders in BL's class (68, 71) were very similar to the length of the pretest of the Gifted and Talented (GATE) fifth-sixth graders in KW's class (70,74). This suggests that these students showed gains in writing fluency that were greater than expected given their age and academic history.

Length of Newspaper Articles. There was one newspaper published in June which contained a sample of stories written across the whole year. This means that it is not possible to use published newspapers as a means to assess increases in length of writing on the computer over the year. The single edition included 32 stories written by 22 of BL's students.

Summary of Length of Writing. The gains in length of essays in this classroom are impressive given that this was a homogeneous group of the lowest skilled third and fourth graders in the school. Given the difficulties that these students had in reading and therefore in the use of the software, it would not have been surprising to see little or no growth in the length of their writing. In fact, the gains in length seemed to increase more towards the end of the year at the same time as use of the computer were more successfully integrated with the curriculum.

To evaluate their improvement, a comparison was made between the length of posttest essays of these low achieving students with the pre-test scores of the older fifth-sixth grade gifted students. There was almost no difference. This suggests that these students made gains in their writing that are beyond what is normally expected.

Quality of Students' Writing in BL's Classroom

The holistic scores for each of the three types of writing assignments are displayed in Table 14.

Pet Desc. Mean:	Sep (pretest) X=2.13 (n=15)		Jun (Posttest) X=2.44 (n=15)
SD:	(.68)		(.57)
Event Desc. Mean:	Sep (pretest) X=1.83 (n=14)		Jun (posttest) X=2.17 (n=14)
SD	(.98)		(.80)
Classroom essays Mean:	Sep-Dec X=2.04 n=24	Jan-Mar X=1.81 n=33	Apr-Jun X=2.29 n=21
SD	(.46)	(.74)	(.69)
Newspaper articles Mean:			June X=2.85 n=30
SD			(.83)

Table 14: The mean holistic scores (0-4) for three types of writing assignments from September to June in BL's classroom.

Quality of Writing Tests. BL's class was the only class in which the rate of improvement on the two different writing tests was similar. The improvement in the quality of the posttest essays describing a pet (an average gain of .31 points on a 0-4 point scale) was almost identical to the improvement in the posttest essays describing an event (average gain of .33 points). However in the other classrooms the increase in quality of the posttest description of an event was more than twice as great as the increase in quality of the posttest description of a pet. (In BMS's class the increase in quality of the posttest test essays for descriptions of a pet averaged .32 points, while the increase in quality of the posttest descriptions of an event averaged .79 points.)

The pre- and posttests were designed to assess increases in a type of writing activity (newspaper writing) that was frequently done on the computer in these classrooms. For reasons already discussed, this classrooms involvement in writing newspaper articles on the computer was minimal. It is possible that if these students had been given pre and posttests writing

tasks that reflected their use of the computer (for example in writing book reports or letter writing), their rate of improvement would be proportionally higher.

Quality of Classroom Writing Assignments. The students' writing on paper did not show much improvement in quality between the first and second period. The average holistic score for the 24 essays collected during the first period was 2.04; the score for the 33 essays collected during the second period dropped slightly to 1.81. From the second to the third period however, there was a gain of a half point on a 0-4 point scale. This is the same period in which the students' work showed a gain in length. These findings suggest that the more successful uses of the computer introduced by BL toward the end of the year had an influence on the quality as well as the length of students' writing during this period.

Quality of Newspaper Articles. The quality of the students work published in the single edition of the newspaper represents a collection of the students' best work over the year. Since the stories were written throughout the year it was not possible to determine improvement over time by using this newspaper. The students engaged in a range of activities on the computer across the year but it is very difficult to compare them because there were varying amounts of help provided by the software and social support for writing was not consistent across the computer activities.

Summary of Quality of Students' Essays. The rate of improvement in the quality of the students work in this classroom was very similar to that of the students in BMS's classroom. The pretests and early classroom work from

these two classrooms was similar to the older fourth graders scoring slightly higher than the third and fourth graders in BL class. The rate of gain in the two classrooms is similar for the description of a pet and for the classroom assignments. However, unlike any of the other classrooms, there was no higher rate of improvement for the description of an event test. Newspaper writing did not play a central role in this classroom and the rate of improvement for this type of writing is no different than for other types.

Conclusion. This classroom showed a unique pattern of student improvement. In BMS's and KW's classrooms the computer was successfully integrated into the curriculum at the beginning of the year and the rate of improvement over the year was steady. In BL's classroom, it was necessary to make adjustments to the software and to the way it was used with students. The integration of the computer activities into the curriculum towards the end of the school year were accompanied by a higher rate of increase in the quality and length of students' writing.

An important dimension in this case study was the growth of the teacher's knowledge as well as that of the students. BL was teaching at a new grade level, learning a new method for teaching writing as a process, and learning how to use a computer and a software system. All of her students were low achieving and in some cases limited English proficient. While any one of these factors alone could make her adjustment to this teaching situation difficult, she was also faced with difficulties in the skill level of the activities was not always appropriate for her students.

Despite there constraints, her students showed a substantial rate of

improvement. Furthermore, she was the only teacher who used the authoring capacity of the computer system to create new software during the course of the year. Because of the skill level of her students, and the additional needs of bilingual students, BL was forced to take the most active role in finding a way to integrate the computer with her teaching objectives. BL's mastery over the system to create new computer tools for her students was very impressive.

Description of Writing in KO's Fifth-Sixth Grade

KO is a teacher with a great deal of expertise in teaching upper grade students how to write. KW's and KO's approach is very similar. Previous to this study, these teachers had worked at the same school sharing teaching materials and strategies for language arts instruction. It was this similarity in approaches to language arts instruction and similar grade level assignments that led us to select this classroom as a control.

Unfortunately, the students assigned to these two classrooms were not similar. The students assigned to KO's class were below average grade level at the beginning of the year as measured by the California Test of Basic Skills. The students in KW classroom were at the other end of the educational spectrum-functioning well above grade level. The students in KO's class are similar in age to the fifth-sixth graders in KW's class, similar in grade level achievement to the fourth grade students in BMS's class and similar in educational history to the low achieving students in BL's class. Because of these differences, this classroom can not in any strict sense be considered a control group for any of the classrooms. However

many of the comparisons highlight differences that may be important in the overall assessment of the effectiveness of the computer facilitated learning environments.

As in KW's and BMS's classrooms, KO arranged her classroom around learning centers. The low scores on vocabulary and spelling subtests of the California Test of Basic Skills prompted her to focus on these areas of skill development. She created an individualized spelling program for each student integrated with the writing process to promote vocabulary development.

About one third of the students in KO's class participated with students from other classrooms in the production of four newspapers over the course of the year. KO held weekly editorial board meetings during lunch for the fifth-sixth grade students who wanted to be involved. During these meetings assignments were given which were often completed during regular classroom writing periods. After the stories were written and edited, the students blocked them letter by letter on graph paper and then they were typed by the teacher.

Length of Students' Essays in KO's Fifth-Sixth Grade

The length of students' writing in this classroom are shown in Table 15. Unlike the other classrooms, there is no clear pattern of improvement over the school year.

Pet Desc.	Sep (pretest)	Jun (posttest)
Mean:	X=73 (n=21)	X=70 (n=21)
SD:	(63)	(30)
Event Desc.	Sep (pretest)	Jun (posttest)
Mean:	X=109 (n=21)	X=56 (n=21)
SD	(56)	(23)

Classroom essays	Sep-Dec	Jan-Mar	Apr-Jun
Mean:	X=58 n=50	X=78 n=73	X=65 n=30
SD	(22)	(36)	(25)

Newspaper articles	Nov	Dec	Feb
Mean:	X=65 n=3	X=72 n=5	X=69 n=5
SD	(21)	(14)	(19)

Table 15 : The mean length of three types of writing assignments from September to June in KO's Classroom.

Length of Writing Tests. In both of the writing tasks the students pretests were longer than the posttests. In fact the mean length of one of the pretests, the description of an event, is 50% longer than the posttest and most other sets of papers written over the year. When the length of this pretest is considered in the context of the other writing done by these students, it it clear that these essays were unusually long.

The students in this classroom, as in the other classrooms, wrote longer posttest essays on the description of pets (mean = 70 words) than they did on the description of events (mean = 56 words). There was, however, a decrease instead of an increase from pre- to posttest for both writing tasks. While the change in length of the pre- and posttests describing a pet were almost the same length (73 compared to 70 words), individual variation over the year decreased. In all the other classes the variation increased with increasing scores. The move toward the group mean may point to an effect of homogeneous grouping of students on the achievement motivation of students.

Length of Classroom Writing Assignments. The drop in average length from the pre- to the posttest essays would be difficult to interpret without the context of classroom writing assignments. It is not likely that the student's writing decreased over time. By comparing the lengths of the pretest essays (73 and 109 words) to the students classroom writing at the beginning of the year (58 words), we can see that these essays were on the average longer than their other written work.

Length of Newspaper Articles. Some of the students in KO's class participated, with students from other classrooms, in the newspaper writing project directed by their teacher. This writing was not done on the computer but provides for a comparison of a similar activity accomplished with the resources provided by the computer and printer.

Newspaper edition dates:	Nov	Dec	Feb
Total number of stories	28	27	22
Total in paragraph format:	7	6	6
Written by other students	4	1	1
Written by KO's students	3	5	5

Table 16: The number of stories in each of the editions of the newspapers that were written by students in KO's class and in a format appropriate for length assessment.

As can be seen Table 16 the newspapers produced were largely composed of entries that were not in paragraph form, making it difficult to compare lengths. (Other articles were lists of responses to questionnaires or surveys, puzzles, or birthday lists.) In the three issues of their newspaper there was an average of 25 articles representing contributions from about a

third of her class. However only 12 of these contributions were in paragraph format and they were written by 5 students. As was seen in Table 15 there was little variation in the length of articles across the three issues (mean lengths of 65 (SD=21), 72 (SD=14), and 69 (SD=19).

Summary of the Length of Students' Essays. While there was some change in the average length of students' writing in this classroom, it did not present the same pattern of steady improvement that was evident in each of the other project classrooms. The average length of students' writing over the year showed only slight increases with individual variation decreasing.

The classroom writing samples do not suggest a gradual increase over the year but rather a high point mid-year with length of writing decreasing towards the end of the year. At the beginning of the year, the average length of students' writing in KO's classroom (58 words) was longer than that of BMS's fourth graders (42 words) and BL's third-fourth graders (38 words) but not as long as that of the fifth and sixth graders in KW's class (95 words). This ranking is consistent with expectations based on grade level and achievement scores.

At the end of the year, however, the ranking had changed. In all the other classrooms the average length of essays had more than doubled over the year. In fact, the average length of the essays by the low achieving third and fourth graders in BL's classroom (68 words) were longer than those of the fifth-sixth graders in this classroom (65 words). The contrast between the increase in length of students' writing in the three "experimental" classrooms and that of this control "classroom" suggests that the computer

facilitated writing environment influenced the length of students' writing.

Quality of Writing in KO's Fifth-Sixth Grade

Improvements in the quality of the students' writing over the year are very similar to the changes in length. There was not a gradual increase in the quality of the students's writing as assessed by our modified holistic scoring procedure (Table 17).

%

Pet Desc.	Sep (pretest)					Jun (posttest)	
Mean:	X=2.25	(n=21)				X=2.11	(n=21)
SD:	(.84)					(.69)	
Event Desc.	Sep (pretest)					Jun (posttest)	
Mean:	X=1.71	(n=21)				X=1.93	(n=22)
SD	(1.29)					(.98)	
Classroom essays	Sep-Dec		Jan-Mar		Apr-Jun		
Mean:	X=2.25	n=50	X=2.14	n=73	X=2.33	n=30	
SD	(.72)		(.61)		(.69)		
Newspaper articles	Nov		Dec		Feb		
Mean:	X=3.6		X=3.8		X=3.6		
SD	(21)		(14)		(19)		
	n=3		n=5		n=5		

Table 17: The mean holistic scores (0-4 point scale) for three types of writing assignments in KO's fifth-sixth grade.

Quality of Writing Tests. The description of the pet pre- and posttest essays were similar in both length and quality reflecting little change over the school year.

While the length of the description of an event decreased by about half from pre- to posttest, there was a slight improvement in the quality of the

writing (+.22 points, SD=1.18). However the rate of improvement was lower than that of BL's third and fourth graders (+.33 points, SD=1.16) and much lower than that of the students in BMS's (+.79 points, SD=1.26) and KW's (+1.02 points, SD=1.07) class.

Quality of Classroom Writing Assignments. The slight variation in both the length and quality of the students' work over the year validates the low rate of change from the pre to the posttest for the students in KO's class. The pattern of change in the quality of the essays was the inverse of that for the length of essays. During the middle three months of school, students essays were longer, but this increase was accompanied by a drop in the quality of students's writing. From mid-year to the final three months, there was a slight decrease in the length and an increase in the quality. The overall pattern was a very slight increase in both length and quality. The rate of improvement however, was much lower than it is for any of the other classrooms.

Quality of Newspaper Articles. The quality of the newspaper articles in each of the editions of the newspaper was consistently high (3.6 - 3.8). But there were very few newspaper articles (3-5 in each edition) that were written in the paragraph format needed to compute a quality score.

While the newspaper project in this classroom was very similar in many ways to the one that occurred in BMS's and KW's classrooms, there were some important differences. KO did not have the resources provided by interactive writing tools, word processors, printers and news networks. The result was that more time was required for assigning articles, providing the necessary guidance in writing and editing the articles, and blocking and typing them

prior to layout. Many of the students used interview forms or survey reports without summarizing the information in their own words. The few students who wrote articles in paragraph format were strong writers and the quality of their work was consistently high across the three editions. While the computer is not the crucial for a classroom newspaper project, a computer and printer can help create a learning environment which devotes more time to composing, editing and evaluating writing and less time to blocking, typing and layout.

Summary of Quality of Students' Essays. The rate of improvement in the quality of students writing across all measures is not as high as in the other three classrooms discussed. On the description of a pet task there was no improvement. The description of an event posttest and the writing assignments in the last three month each indicate a slight (.19 and .22 points) increase from the beginning of the year. The gain over the year is not consistent; scores dropped midyear. A newspaper project without the help of computer tools was effective in helping students learn many important things about journalism, but did not provide the same focus on writing skills.

Standardized Tests of Language and Reading Skills

The California Test of Basic Skills was administered in May in KL's school district so we were able to use these to examined the students' progress in this classroom. Table 18 shows the grade-level equivalents for the subskills measures in the language portion of the CTBS for KO's students.

LANGUAGE	OCT	MAY	READING	OCT	MAY
Spelling			Vocabulary		
Grade level eq.	4.1	5.1	Grade level eq.	4.1	4.6
SD	(1.1)	(1.5)	SD	(1.4)	(1.8)
Mechanics			Comprehension		
Grade level eq.	3.3	4.1	Grade level eq.	4.3	4.8
SD	(1.3)	(1.8)	SD	(2.0)	(2.3)
Expression					
Grade level eq.	4.1	4.6			
SD	(1.5)	(1.8)			
TOTAL			TOTAL		
Grade level eq.	3.7	4.5	Grade level eq.	4.2	4.7
SD	(1.3)	(1.6)	SD	(1.6)	(2.0)

Table 18: The results of the California Test of Basic Skills (CTBS) standardized testing for KO's fifth (n=14) and sixth (n=11) grade classroom expressed in grade level equivalents, at the beginning (Oct) and end of the year (May).

If all students were functioning at grade level, the average grade level for the class would be 5.5 in October and it would be 6.3 in May. As can be seen from the scores in Table 198the class scored one grade level below average in October in all language and reading subskills. At the end of the year the students remained below grade level.

A comparison of the reading and writing subtests suggests that the writing program in this classroom was effective in improving students' language. While the students show a gain of .5 for the reading skills, they show the expected gain of .8 for the language skills. The students show the highest gain in spelling, an area in which KO had placed a special emphasis.

The other classrooms in this study did relatively better on all measures of writing used in this study. However, the students in this classroom did achieve one grade level in language arts which is higher than is expected for students who began the year so far below grade level. This suggests that the

writing program used in this classroom without the use of the computer writing tools was an effective way to teach students language skills. The evidence from the other classrooms suggests that the integration of the computer writing tools with the approach to writing used in this classroom would lead to a very effective writing program.

Conclusion

The students in KO's class do not show the same degree of improvement in their skills as did the the students in the other classrooms discussed. Their writing pre- and posttests do not show any gain in length or quality. The students showed the greatest improvement in both the length and quality of essays during the middle of the year, while scores fell off towards the end of the year. The production of newspapers without the aid of computer writing tools resulted in more time required for making writing assignments, guiding writers and the blocking, typing and layout of the articles. This left little time for the evaluation and revision of writing that was central in the newspaper writing experiences in the other classrooms.

While the performance of these students on writing tasks was not impressive when compared to the students in the other classrooms, the results of standardized tests (CTBS) suggest that these students did show the amount of gain that is expected for this time period.

Features of Functional Writing Environments

I have described the development of writing skills in four classrooms over a period of one year. I will now briefly compare the features of each

of the classrooms and summarize student gains. From this comparison of the case studies we can make inferences about which features seem to contribute to the success of functional learning environments.

Functional Writing without Computer Tools

KO is an experienced teacher working at a familiar grade level without a computer or any computer writing tools. Teaching writing is clearly one of her strengths; her instructional strategies are very similar to those of the other teachers in this study. An indication of her dedication to language arts instruction is the school newspaper project that she organized and implemented.

Her classroom consisted of a relatively homogeneous group of low achieving students. Their group scores on standardized testing were about a year below grade level in all academic areas. Their educational history suggests that every year they will fall slightly further behind their grade level. While this expected pattern occurred in reading, the students' scores in the language area indicated a normal year's gain.

The students in KO's class did not show the same degree of improvement in their skills as did the students in the other classrooms discussed. Their writing pre- and posttests did not show any gain in length or quality. The students classroom assignments indicated the greatest improvement in both the length and quality during the middle of the year with scores falling off towards the end of the year. The production of newspapers without the aid of computer writing tools resulted in more time required for making writing assignments, guiding writers and the blocking, typing and layout of the

articles. This left little time for the evaluation and revision of writing that was central in the newspaper writing experiences in the other classrooms.

In this case study, a skilled teacher who taught writing as a process from pre-writing to publication was able to help low achieving students improve their writing skills. Even though gains were evident on standardized testing the students essays over the year did not show the degree of improvement that was evident in all the classrooms using computer tools.

Computer Tools: Necessary but not Sufficient

BL faced a number of new experiences besides participation in this project. She was teaching at a new grade level, developing a bilingual program and learning a new method for language arts instruction. Like KW, her knowledge of computers and the computer writing tools was minimal. But unlike KW, she could not count on her students to help her learn. While any one of these factors alone could make her adjustment to this teaching situation difficult, she was also faced with difficulties in using the available software with her students. Many of the students had difficulty reading the writing instructions on the screen. It was also important to have the same computer task available in Spanish and English.

In BMS's and KW's classrooms the computer writing tools were successfully integrated into the curriculum at the beginning of the year and and the improvement in the quality and length of students' writing over the year was consistent. In BL's classroom, the students' inability to read the

information on the screen made it necessary to make adjustments to the software and to the way it was used with students. The more successful introduction of computer activities created by BL towards the end of the school year were accompanied by a higher rate of increase in the quality and length of students' writing.

Despite these constraints, her students showed a substantial rate of improvement. The increase in the quality and length of student essays in this classroom are impressive. Given the difficulties that these students had in reading and therefore in the use of the software, it would not have been surprising to see little or no growth in the length of their writing. The fact that these gains begin to show up towards the end of the year, at the same time as the students were using the materials created by BL suggests that the successful integration of the computer with the writing curriculum may have had an influence.

Because of the skill level of her students, and the additional needs of bilingual students, BL took an active role in creating new activities to integrate the computer with her teaching objectives. BL's mastery over the system enabled her to create new computer tools for her students and a system that was flexible enough to allow for re-structuring made it possible to create a functional environment for these younger bilingual students.

An important dimension that this case study adds to our knowledge of writing with computers is the critical role of teacher's knowledge and the flexibility of the computer writing system. Computers and computer tools by themselves will not make students better writers. But computer tools used by experienced educators can create effective learning environments.

Computer Tools and Teaching Knowledge

KW, a teacher with a great deal of experience in teaching language arts, was teaching at familiar grade level, although this was her first experience with "gifted" students. Prior to this study she had minimal experience with computers. While she seen some demonstrations of the software, she began the year with much less computer knowledge and experience than some of her students. She relied heavily on students who learned quickly to help her and other students find solutions to problems that arose.

While at times struggling to master the computer and the writing tools, KW had little difficulty in extending her teaching strategies to include the computer as one of many work stations in her classroom. The students were quickly able to use the computer tools to extend their writing. The students in this class showed a pattern of increase in writing skills well beyond their grade level. However it is difficult to assess the degree of influence of the computer writing environment in this classroom for two reasons: (1) The students in this class were expected to make more than a year's progress; (2) judging their rate of improvement was difficult because of a ceiling effect in most of the measures. This effect was evident in project testing, evaluation of students' writing and in standardized testing by the school district. Even with the ceiling effect, the students in this classroom showed gains in writing that were similar to those of the students in BMS's classroom.

Comparing the students' writing across the year in different situations

provides important information in understanding the features that contribute to a functional writing environment. The students' interest in editing each others work and the increase in the quality of writing doing cooperatively at the computer highlight peer review and collaborative writing as important dimensions of the learning environment described.

Computer Tools, Teacher Knowledge, and Computer Expertise

BMS had prior experience teaching fourth grade students and had both training and experience in teaching writing as a process. Her classroom was organized in learning centers and in the year before this study, she had experimented with computer writing tools to help students learn how to write expository texts (Miller-Souviney 1985). She served as a valuable resource in developing strategies for integrating the computer into the writing curriculum in all the classrooms. As in many classrooms, the students in this class represented a heterogeneous mix of skill levels with the class average at grade level.

The integration of the computer into the writing curriculum went very smoothly. The students in this class were able to master the use of a new form of technology for writing and do so while improving their writing and reading skills well beyond their grade level expectation. The use of student response groups for editing each others writing seemed to play an important role in the development of writing skills.

The evidence from this classroom indicates that a skilled language arts teacher with some prior computer experience can use the computer to create functional learning environments for students that are very effective in

teaching language arts skills. The standardized test scores provide strong evidence that the students in BMS's classroom made significant gains in the quality of their writing over the year. The gain, on the average, of 3 grade levels in language mechanics and 2 grade levels in language expression are very clear. These findings were particularly noteworthy as gains in writing often do not show up in standardized testing. We know from past research that editing in context is more effective than completing grammar exercises to increase students' skill in writing. This classroom provides the unusual situation in which traditional grammar exercises were replaced by having students serve as editors of each others work. It may be that editing the work of others is even more effective than feedback on one's own writing.

I conclude by returning to the question that I asked at the beginning of this chapter: Does a computer improve students' writing? While it is difficult to say how much of the improvement, if any, can be attributed to the computer alone, the results of our research suggest that the functional writing environments that we created using computers effected the length and quality of students' writing.