CHAPTER 7:

COMPUTER ACTIVITIES IN A BILINGUAL SETTING

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Introduction

The purpose of these introductory remarks is to specify the research approach used to study the introduction of a computer into a bilingual classroom. In particular, we want to make our assumptions explicit, discuss how our approach is related to our previous research in bilingual classrooms, and preview key issues. We will then describe in detail the bilingual classroom and present examples of the introduction, use and development of the computer and its relation to teaching practices.

The most obvious characteristic of BL's students concerns language background; of the 30 students in the class, 10 were limited English proficient students (LEP) receiving bilingual instruction. Besides the bilingual character of the classroom, there were other important factors for understanding the impact of a computer in the classroom. Most notably, all of the children, regardless of language background, were classified as poor readers. More than the other classrooms included in the study, this class revealed the special issues confronting poor readers and their teachers when computers are introduced into a classroom. As third graders, these children were also the youngest students in our sample. Thus, not only were many of the children LEP, but they were poor readers and young, a combination of factors important to consider in analyzing the results of this study.

Furthermore, BL was one of two teachers who started the project as a computer novice. Thus, this classroom represented the type of classroom that the introduction of the technology is supposed to assist, one that contains "hard to teach" children who are taught by a teacher with limited computer knowledge.

The characteristics of this class allowed us to address three important issues regarding the use of computers in classrooms: (1) What does a computer-novice teacher go through when trying to use a computer in the classroom? (2) What problems do poor readers encounter in using computers? (3) How can computers be used with limited English-speaking children?

We tried to implement the same computer activities across classrooms in this project, in order to examine how the activities changed or were modified depending on the specific teaching-learning circumstances found in each classroom setting. In a real sense, therefore, each classroom formed a point of comparison for the others. The bilingual classroom experience reported in this chapter should be viewed in the light of the overall set of comparisons.

Assumptions Underlying Our Approach With Young LEP Students

Previous chapters describe our general approach to the use of computers in classrooms. This approach emphasizes (1) using computers as tools to accomplish well specified educational goals, (2) embedding computer activities in functional educational environments and (3) providing varying degrees of social support for novices, both teachers and students, in using the machines. We assert that there is no single prescription for effective computer use in classrooms. Furthermore, the search for a single program is not desirable. Instead, we propose general principles for the use of this new technology. The specific application of these general principles will differ depending on instructional circumstances. Consequently, there is no single bilingual approach to the use of computers; each program needs to be developed in the context of a given instructional setting and its goals.

In addition to our general approach, a set of specific assumptions underlie our work with LEP students, which influenced how we worked with the teacher as she used a computer in her classroom.

Emphasize Academic Development. In previous work (Moll and Diaz, 1984) we have documented the common practice of reducing the intellectual demands of the curriculum to match the children's limited English proficiency. This practice acts on the assumption that LEP children have no skills or are unable to profit from instruction until they became proficient in English. A similar situation has developed in the use of computers in education: affluent students are exposed to programming and problem-solving; poor students, especially language minority students, are relegated to drill and practice (CSOS, 1983; Boruta et al, 1983).

Our approach seeks to overcome this stratification by implementing similar goals and activites regardless of English language proficiency. Therefore, finding ways to organize the social environment to ensure the children's participation in advanced computer activites was an overreaching goal of this project. We wanted children in all project classrooms to engage in comparable computer activities. Consequently, it was not a matter of using computers, for example, for writing and for bilingual education, or problem solving and for bilingual education, but a matter of using computers to organize academic activities to achieve the same high academic goals in different teaching-learning environments, including a bilingual setting. Therefore we address the use of the computer to teach oral language development in English only in so far as that topic relates to the attainment of broader academic goals. We also address the development of bilingual software as a means of facilitating participation in advanced computer activities, not as an isolated technical issue.

Capitalize on the Children's Skills. We also wanted to develop computer activities that made biligual skills an asset, or at the very least, took advantage of the children's oral langugage and literacy skills in Spanish. We viewed the introduction of the computer as a broader pedagogical issue regarding effective bilingual instruction, not as an isolated technical issue regarding the teaching of skills to use a computer or teaching students to become computer "literate."

Capitalize on the Teacher's Skills. We realize that an attraction of drill and practice is that it can be done without much teacher involvement. Our approach requires more active and direct involvement from teachers. This need for involvement posed a dilemma. Given that the bilingual teacher was a computer novice, we needed to organize activities that helped the teacher to use the computer in sophisticated ways while she developed expertise in the use of the machine. In order to counter the tendency to reduce the level of computer activities to match the children's low academic level and the teacher's lack of computer knowledge, we tried to design a system of support for the teacher's use of the computer in the classroom.

Implementing Computer Activities

Computers are the rage in education. But nothing seems to intimidate teachers more than the idea of using the machines in their classrooms when they are not facile in their use. It is only a slight exaggeration to claim that this was BL's situation at the beginning of the project. Much to her credit she persevered, even after some initial discouragement, to implement computer activities systematically and successfuly, gaining competence and confidence as the year progressed. In the following section we describe the introduction of a computer into her class.

The First Phase: Getting Started

In a real sense, the first three months of the school year were "on the job training" for the teacher. Her knowledge about how to use computers was minimal and she was not sure just what to expect from either the machines or the researchers in her classroom. But as we will discuss later, the uncertainty of this first phase allowed her to experiment with different activities and approaches, and to discover how much she could do as well as the constraints that she faced.

There are several issues related to "getting started," most were quite pragmatic. In particular, as she assumed responsibility for teaching with a computer, she wanted to make sure that she did not neglect her other teaching duties, which were considerable, and that the LEP children did not fall behind the rest of the class.

Organizing Computer Use in the Classroom. The first concern was finding a way to structure computer use in her classroom. This concern was reflected in the care with which the computer routine was organized (see Chapter 2). In brief, a computer corner was established and a schedule posted on an accompanying chart specifying which children were supposed to be working on the computer, on what day, and for how long. Software set aside specifically for children using the computer during math, reading or homeroom time. Monday mornings were established as the time to provide instructions about new assignments or to introduce new software. Assignments were monitored by the teacher in order to assess the children's progress or problems. Discussions were held with colleagues in the project on how to improve the presentation of materials.

This routine worked well. The children learned it rapidly and adhered to the schedule readily and consistenly. By the second week most of the children were following the "computer schedule" without teacher supervision.

One consistent and important finding is that the computer activities retained their motivational qualities throughout the year. Rarely did a child resist working on the machine. During those times that the schedule had to be modified temporarily, abbreviated school days, for example, the teacher needed to reassure the children that she would rearrange the schedule so that everyone had equal access. That computers initially excite and motivate children may seem evident, particularly given the popularity of computer arcades, but considering the repetitiveness of most curricula and the negative (dull) conditions usually associated with classroom work, it is impressive that the computer activities were able to elicit enthusiastic participation from the students all year, regardless of the changing nature of the software. It may well be the computers' arcade and game history that make them such a powerful "lure" in the classroom, even with children that have little or no previous experience. During the first two to three weeks, small groups left their desks to "hang out" around the computer watching others work, sometimes making comments to the users or among themselves. Such behavior is reminiscent of what youngsters do at computer arcades, especially when they want to learn a new game (or when they are broke!).

The computer-using routine in this classroom was also characterized by flexibility and diversity. Instead of providing only one way of introducing the students to computers (e.g., programming or keyboard practice), the teacher made available "multiple entry points" to computer use (Levin & Souviney, 1983; LCHC, 1982). About 10 software programs were used during the initial six weeks (see Chapter 2). In some cases software was changed or its use postponed because it proved too difficult for the children. However, in general, children who were unable or unwilling to engage in a particular task were offered alternatives. That is, students were not excluded or relegated to lower-level work when they had difficulties with a particular program. Instead the software was replaced or modified, or social assistance was increased. A rapid means to create multiple and varied environments for learning is one of the advantages of an interactive computer system that provides dynamic support to teachers and students alike.

During the initial weeks the teacher also tried several ways of relating the computer activities to other curricular tasks. For example, the children were asked to write brief essays that were then transferred to the computer. In such cases, the paper-pencil writing activity functioned as preparation for writing with the machine, and the machine became a context in which students' writing with pencil was expanded or revised. Another example comes from an English lesson with the LEP students in which the teacher asked the children to make sentences using computer terms.

Clearly, the introduction of the computer into the classroom created additional work for the teacher. Not only was more preparation required, but she had to pack more activities into an already crowded curriculum and deal with the extra interruptions from children seeking help. Most of the children's problems during the first phase involved computer or program operations --mistakes or problems in making the machine or program work. Throughout the initial phase the children relied on the teacher as the primary source of support and information. This reliance is not surprising, given that the class was teacher-centered to a great extent. This state of affairs underlines two important considerations in computer use: 1) computers do not stand alone; 2) regardless of the presence of the machine, the teacher must still teach. Teachers must organize activities involving the computer just as they must organize activities for reading, math or science. They must schedule work routines at the computer just as they must plan reading group rotations or excursions to the library. There is no doubt that the act of introducing a computer into a classroom is a lot of work. Much of this work is very frustrating as something always seems to go wrong: a program does not run, the screen goes blank, the kids do not understand the directions, they forget to save what they have written on disks, etc.

As research into classroom computer use continues, it will be important to determine whether the introduction of a computer causes special and particular problems, or whether the problems are similar to those associated with the introduction of any new curricular activity. Initially, all these problems disrupt the flow of the classroom routine. Consider some common examples we observed.

> "John asks BL if it is time to go on the computer. He is scheduled with Aaron (who is absent) at this time. BL chooses Christian to be John's partner. They read outloud the instructions on the monitor. Christian is a slow reader. John is a better reader. They seem confused. Christian says, 'I gotta go get Ms. L.' He raises his hand. BL acknowledges and says she'll be there in a moment. Christian is still raising his hand. He stands up. BL comes over. She starts them over by pushing CTRL-Reset and tells them to type in PR#6 and leaves. The boys type in PR#6 and get a syntax error. Christian again wants to get BL. She is busy and doesn't see his raised hand. John is quiet until he says 'Press CTRL-Reset'; Christian: 'How do you know?'; John: 'I know'; Christian: 'No you don't. Ask Ms. L.; John: 'You ask her.' Christian stands again and BL comes over, retypes PR#6 and leaves again."

Most of the children, as in the example, go get the teacher as soon as they encounter difficulties. Practically all children we observed during the first phase sought help from BL every time they used the computer (see Chapter 6 for details).

To avoid being interrupted so often, the teacher posted instructions near the computer or wrote them on the section of the blackboard nearest the machine. We found only a few examples of written instructions being used effectively by the students to help themselves proceed with the computer activity. The issue of reliance on social instead of print resources is a general pattern in all classrooms. The pattern may have been exacerbated by the children's low reading levels, an issue that we examine next.

Bilingual Support in Interacting with Software. Perhaps the most pressing problem in this particular classroom was the children's low level of reading. Software programs, even the simpler ones, require children to read, either to follow intructions or as part of the activity. We observed many of the children unwilling to read the text on the screen. A well documented consequence of being a poor reader is that one avoids text (cf. Hood, Cole and McDermott, 1980; Kozol, 1980; Rueda and Mehan, 1985).

During the "start up" phase, most of the software programs were in English only. Thus the LEP children found themselves at an additional disadvantage. As mentioned earlier, providing all of the children with a comparable curriculum regardless of their English language fluency was one of BL's priorities. The teacher provided instructions in Spanish and translated key terms to facilitate the LEP children's participation in the same activities as the rest of the class. Below are three examples of how this help was given:

The game is called Shark, the children select the coordinates to fire a harpoon at a Shark; if the harpoon misses the computer provides feedback to help the children adjust the aim. Pat and Monica, two LEP girls are playing the game with the help of the teacher. The teacher first goes through the "booting up" motions, asking the girls questions in Spanish to ascertain whether they understand the procedures (Que es lo primero que tienen que hacer?; Como vamos a saber si la pantalla esta prendida?). The girls either answer or do the action required.

The program is booted and the first question appears on the screen (What is the name of your school?). BL translates the question into Spanish and tells the girls to each type on letter at a time. The girls type in the name of the school and BL asks them what they should do next after they finish. Monica points to the shift key and BL says no. Monica then points to the Return key and BL says yes. As the game continues BL translates the instructions into Spanish to assist the children.

With the teacher's help Monica finally gets a hit. Her partner, Patty, takes her turn and she gets a hit on two tries. As the girls seem to get the idea, BL continues to provide Spanish instructions, but little by little she introduces Engish. The teacher's goal in providing support was to help the girls participate in and understand the game, so that they could play without her constant supervision. Because the teacher could not possibly take the time to help all of the LEP children every time they used the computer, the observers, who were all bilingual, agreed to provide similar help as needed in engaging the children in the task. In the next example the observer assists the children with Speed Read, a game all of the children found difficult because of the rapidity with which words were displayed on the screen.

AM (the observer) helps the children get started by providing a Spanish translation of English instructions, similar to the example above. As she reported in her field notes:

> "Again the words flash on too fast, even at slow speed. The words that flash are in Spanish (they have been traslated but the instructions remained in English), but Alberto did not realize this. I think this is because all of the instructions were in English and I translated, and then when the words flashed on it was so quick that he didn't notice it had switched to Spanish. In fact, at first he didn't believe me when I told him they were in Spanish. Because the words were flashing fast, the boys would look at me to see what to do. What I did was say the word aloud and then see if they could type it in within the amount of time given. About 75 percentof the time they were able to type the word in within the amount of time given, if I told them the word. This does not mean they always spelled itcorrectly. The other 25 percent of the time, time ran out and the computer would count it as wrong.The boys wanted to try again so we went through it once more. It was the same list of words. This time I had them watch the screen closely and see if they could do it on their own, but it wasn't very successful. They would be able to see and be able to see and read the first few letters and then the word would flash off."

In this instance the Spanish translation helped the children get started, but the game proved too difficult. However, notice that the children were able to write the words most of the time if they were said aloud by the observer, showing that the difficulty was in decoding rapidly, a common problem with young readers. In the following example note that the English monolinguals have the same problem.

> "Christian and John are doing Speed Read. After some help from AM in getting the program started, John reads the instructions on the screen. Words then flash on the screen very fast and he is supposed to spell it but only has a certain time to do it in. The boys take turns, one word at a time, and try to spell it... The boys are not getting any right. (They decide to try another program.) ...there is a lot of text (on the screen)...John reads one screen full. I read the other two screens of text...Christian is impatient and wants quit and skip the instructions and go on to the next screen before we were finished."

The comparison shows that it is not solely the LEP children's lack of oral language skills that makes working with the computer difficult; the English monolingual speakers had similar problems. What both groups have in common is that they are poor readers and interacting with computers independently requires good reading skills. One way to alleviate this problem would be to not allow children to do any computer work until they became proficient readers. But this practice reduces access to the machines and denies potential benefits to the very children one hopes computers will help. A second way would be to select software that minimized the requirement to read. But that alternative eliminates the most interesting and potentially useful software.

The teacher's alternative was to compensate for the children's lack of reading skills in ways that allowed them to interact with computer programs. The teacher provided verbal and reading help to the children as they worked on the computer. This alternative incorporated the principle of dynamic support which has been discussed throughout this report. In this particular instance, the assumption was made that with this help and the progress in reading expected from regular reading lessons, the children would be able to hold their own in a few weeks. Indeed, during the final three weeks of the first phase we started noticing that some of the children were beginning to proceed with less help, as the following examples illustrate:

> "Adrian and Alberto sit down and ask me what to do. I speak to them basically in English and switch to Spanish to clarify an instruction. ...The text was coming out (on the screen) in English, not in Spanish. At first, when they complained about being in English, I told them they could still do it, since usually the introduction to these programs are not translated... We tried 'Starwars' (from Storyland) ...but the prompt lines were in English and they were discouraged by that. I forced them to read it and then I would translate.
>
> They push the last choice and must continue the story themselves. They don't understand what they are supposed to do. I explain in Spanish that they are to write on the computer and finish the story themselves. I read to them what they've written so far and tell them to continue... They proceed by taking turns in selecting the sentences to make the paragraph.

When it was time to stop they are unsure how to proceed, so AM had them read the prompt line. The prompt lines were in English which intially made them complain and not try, but AM had them read the prompt and translated what they did not understand. In this manner, they got through ending, writing and saving the text. The children were not interested in reading the first paragraph they did, which was based on their selections, but wanted to read the second paragraph which they composed on line. The next week they manage to spend more time composing.

Adrian asked AM what he and Alberto are supposed to do. She points out the disk and Adrian complains that it is in English and that they want it in Spanish. AM tells them that the disk is also in Spanish, so they put it in and the program starts. The intructions are in English so the children turn to AM to find out what to do next. She tells them to read it and as they read she elaborates on each point. Adrian chooses to write about news and they start to write. Alberto says something referring to Adrian getting into trouble. Adrian tells him to go ahead and write about that, and they both look at AM for confirmation that it is okay. The boys start discussing particular words and what to write and for the next 10 minutes they help each other write. AM tells them that their time is up, but Adrian does not want to stop. With AM prompting they get through the procedures for leaving the program, naming the text, switching disks, saving the text, and turning off the computer.

Thus, we have indications that these children, among others, began to function independently, at least to enter text. However, they still needed help leaving the program and saving what they wrote.

Summary. The first three months of the school year involved implementing a schedule for computer use in which everyone in the class had equal access to the machine and in which all of the children, regardless of English language fluency, would engage in comparable tasks. What is most clear from our observations is that introducing a computer into a classroom requires extra effort from the teacher, especially if the children are poor readers. It is simply not the case that all the teacher needs is good software and a sequence of activites and the machine does the rest. The use of the computer is always mediated by classroom social processes, most of which are controlled by the teacher's previous procedures for organizing instruction and constraints imposed on the classroom from outside.

Instead of organizing a fixed activity schedule for the children using a predetermined sequence of tasks, the teacher presented the students with a variety of software programs and tried to relate the computer activities to other aspects of the curriculum. Progress was slow. It took the children several attempts to learn computer operations and program procedures. Although mastering operations and procedures was particularly difficult for the LEP children, the teacher did not relegate them to less demanding computer activities that would match their low level of oral and reading proficiency. Instead, the teacher sought to provide the social resources necessary to permit these children to engage in the tasks the rest of the class was doing. This strategy proved to be laborious, but effective. By the end of December, there were indications that the children, including the LEP students, were overcoming difficulties with procedural matters and participating in computer activities profitably.

The Second Phase: Developing Expertise

During the Christmas break, we evaluated our experiences from our first three months of observations. One thing was clear: we did not have any spectacular results of children performing wonders with computers. However, scrutiny of our notes and videotapes revealed changes in the children's computer work, changes which served to establish new conditions for computer use during the remainder of the year. After discussion with the researchers and the other teachers on the project, the teacher decided to have the children concentrate on a single software program for a prolonged period of time. In particular the teacher was interested in implementing the Computer Chronicles (CC) with the entire class. We hoped that by constraining the number of computer activites we would help ease the burden on the teacher, allow her to learn new software programs and provide the children more time on task with the same software. We also obtained a printer to use in the class, an addition that proved to be most useful because it provided the children with tangible results of their work on the computer.

The teacher was also interested in developing her own software, tailored to the LEP children, to supplement their work on Computer Chronicles. During the second phase she learned how to program interactive texts and developed Storyland stories in Spanish. This innovation proved successful in providing the LEP students with yet another entry point into computer activities that had an English-language equivalent they would eventually use. It also provided the teacher with more control over the functioning of the machine. In a sense it allowed her to understand and participate in the computer activities at a different level. Instead of being only a consumer of what others gave her, she became a producer of activities. Our initial observations in January gave us the impression that the children (see Chapter 5 for more details) were indeed much more familiar with the procedures and spending more time on the content of the programs. This was certainly true of some of the children, although we also observed many problems. The following is a typical example of the children working competently with a minimum of help:

> "BL called Nicola and Julie to the computer. She asked them to work with 'The Adventures of Horus,' a user controlled program in which the students can either select from available sentence fragments to complete a sentence or write their own story. The girls look for the disk and finally find it.
>
> They turn on the CPU. Nicola types in first 'Nicola and' Julie then types in her name 'Julie,' Nicola hits Return. N: 'You do this next one' J: 'Ok, what do we do?'
>
> Horus starts. The first turn is to type in the name of an animal. Nicola types a name in despite it being "the next one" which Julie was supposed to do. Julie does not seem to mind. Nicola is typing in all the commands... The girls discuss what color to enter on the next turn. The third choice is ok with both of them. Nicola goes to type it in and then says "No, you do it" to Julie. J:"ok" and types in the color. Nicola hits Ctrl-C. Nicola is seated at the 'keyboard seat.' Next turn, the girls must enter a wish--Horus' wish. J: "I wish I could have a dog." N: "um...or a cat" J: "Yeah,

I wish I could have a cat." Julie starts typing in the sentence. The girls seem to be taking turns, one word at a time, for the first three words. Then, Nicola finds a mistake on the third word, she erases "the whole word" and retypes it. She finishes the sentence.

Nicola had gotten up and now comes back with two reading books. She uses the title of the top book, Superfudge, to use and enter as a type of book...

N: "You do this. I´ve been doing most of this". When Julie moves over to type, Nicola moves her hands away and takes over.

The girls needed help with "cooking utensil." They didn´t know what that was exactly... They need help with an adjective for the story... Nicola and Julie finish the story on the computer and are now reading their text on the screen. They saved it on their own."

Although the girls were able to use the program with little difficulty, they obtained strategic help from three different sources available in their immediate environment. One was the software program itself, which provided them with the option of selecting pre-written sentences or the opportunity to compose their own. This closing feature provided a clear structure for the students to place their sentences that served to guide their writing, and a goal related to that structure. A second source of help was each other. They collaborated, for example, in typing, making selections, and composing. A third source of help was the observer. They turned to the observer for assistance, clarifying procedures, defining words, and so on. As the children´s performance improved they sought help from sources other than the teacher. That is, the source of support shifted from reliance on the teacher to other places in the environment.

This shift in ways of working with the computer was also evident with the LEP students. In the following example the children were working on a Spanish version of Storyland that BL developed specifically for her class.

"As they start Patty reads the text outloud while Monica whispers along with her. They choose ´creando oraciones simples´ (creating simple sentences).

Monica tells Patty which number to select, and then Patty types it in and hits return. This division of labor was designated by Patty and agreed by Monica. Monica now has taken over reading what is on the screen outloud. They read through most of the selections before deciding. Sometimes Patty would not agree with Monica's choice, so she would suggest some other one and wait for Monica to agree...BL announces "5 more minutes."

Patty is now reading and telling Monica what # to select, and Monica types it in and hits return... The girls are now on their fourth sentence. Patty calls me to see because they wrote a funny sentence..."el lobo escapo dentro de la television y tiro al maestro a la calle." They do one more.

Nicola & Julie come over, it is their turn now. Patty & Monica turn off the monitor and take out the disk."

As in the previous example, the students relied on each other to complete the task, shifting the division of labor as needed. However, in our observations of the same children a week later, knowing computer operations did not guarantee that the children would interact with the content usefully.

"The girls are typing in their names. Monica tells Patty to write her last name too (Patty is writing her name in first) and then Patty writes her name on the blackboard to check her spelling on the computer. Monica types in her whole name too.

The girls get to the first set of selections in Storyland. Patty is on the keyboard. She turns to Monica 'poncho peludo, number three,' M: 'No peludo' She looks at the screen and Patty just pushes the number. Patty just wants to push 'lo que sea.' (whatever). Patty is doing the typing and the hitting of Return. She reads out loud a little, then seems to get tired or bored because she verbalizes, in English, the same selection for three turns after that; she just picks a number/selection without reading the choices. Monica, on the other hand, likes and seems to want to read the choices available but Patty is too fast and passes on to the next set.

The girls start on a second paragraph. M: 'yo le poncho los numeros y tu el Return' (I hit the numbers and you Return), negotiating about turn taking. P: 'Tu punchas el Return y yo el que quiera" (I hit Return and I hit whatever I want.). Monica accepts this. The girls continuue. Patty still choosing numbers without reading the text. She begins to humm, quite loudly, Rudolph the Red Nosed Reindeer. The girls finish the paragraph. The computer is prompting them to answer Yes or No if they want to continue. They ask me to choose for them. I say No (because of time). They start

> the saving procedures. They switch disks when I tell them to. I read the prompt lines in English. They seem to understand. They want to see what they wrote and it is put up on the screen. They read it aloud together.
>
> The computer prompts asking if they want to print their text. I explain the printer and what "to print" is. We go through to get two copies."

The same inconsistent performance was also evident with the English monolingual children:

> "Mandy says to the me (the observer) that she (Mandy) does not know what they are supposed to do. I point to the blackboard where BL had written the assignment. She looks and gets a puzzled look. AM: ´What does it say?´ M:´Number one Computer Chronicles.´ AM: ´And after that?´ She reads the rest of the assignment but does not seem to understand yet what to do...
>
> (The observer explains what to do and the girls start the disk; they decide to write about a TV program.) Mandy reads aloud what is on the screen. R: ´Do you know one?´ M: ´Webster´...Ruth suggests to write that the program is good. M. ´Are we just going to say it´s funny?´ AM: ´You write as much as you want.´...Mandy turn back to the computer and screen. Ruth hits CTRL-C after that one sentence. Mandy complains taht they wanted to write more. I tell them to push CTRL-C when all done. M: ´We´ll have to start all over again!´
>
> The girls enter one sentence of their review. It is a little longer that the other one. (Ruth hits CTRL-C.) M: ´You did it again!´ R: ´I did not.´ Mandy hits CTRL-Reset and says ´we have to do it all again!´ after only one sentence."
>
> The two girls proceed in a similar way for the rest of their time, completing barely one sentence in their allotted time.

A few days later, just when it seems that these girls will never get anything done, they are much more coordinated and on task.

> "Ruth and Mandy start. They take turns writing out the date. They ask me what section they are to do. I point to the board where the assignment is written up. The girls arrive (on the computer) to where they enter their story. They are going to enter Ruth´s story. Ruth begins typing. Mandy corrects a mispelled word. M: ´This is my turn,´ and she types in a word. R: ´I do the next.´ They are dividing up the task word by word. After the first sentence , Mandy tries to hit CTRL-C; Ruth and I stop her. AM: ´When do you hit CTRL-C?´ M: ´When you are done.´ AM: ´When you are all done, otherwise the computer thinks you are all done, finished with your story.´ M: ´We have to make sure this makes sense.´...

M: ´What is next?´ R: ´my friend...you write my." Mandy types it in and Ruth does the next word...M: ´We never start a sentence with and. Never!´ She backs the cursor and erases ´and.´... Ruth suggests, ´Me and her.´ Mandy responds that ´Me and her doesn´t make sense. Me and Danielle does.´ They decide that is what they will type."

The girls continue to discuss the content of what they are writing as they compose and check for mistakes. They also comment that they are writing much more now than the last time. Throughout this process the observer provides strategic help by making sure the girls don´t get bogged down on the lower order computer operations, such as when to push CTRL-C, that may distract them from the purpose of the activity which is writing a narrative.

A striking example of how much this "lower-order" help can ease constraints that may limit what the chidren can in fact produce is provided next:

"Patty is on the computer. Her partner Monica is absent. BL asks me to be with Patty. I go and ask her if she knows what she is to do. She says no but then asks if she is to get her story (for CC); I tell her yes. She has written on both sides of the paper on her Perfect Friend. She boots up and we get to where she is to begin writing.

She starts typing in the story, following word by word. She is real slow but seems to know where most of the letters are on the keyboard. I ask her if she wants me to type and she tells me what to put in. She agrees because ´it will go faster, verdad?´ She dictates to me until she finishes what is written on the paper.

I ask her if she wants to say or write more. She says yes. I ask her what and type it as she tells me. I start telling her she has to watch closely and make sure that I don´t make any mistakes... She started beginning sentences with ´and´ so I ask her if a sentence can begin with ´and.´ She says yes; I explain that and is a continutation... I give her an example of how she can begin her next sentence without ´and.´ She continues dictating. I don´t write a period unless she tells me, though sometimes I will prompt her and ask her if it is time for a period or not."

Patty saves her text and they get three printouts of her story. Contrast what she wrote, for example, to what Gregg was able to do unassisted. Patty´s draft is over twice as long as Gregg´s or any of the other examples we accumulated. One consequence of eliciting this extended amount of text in a short period of time from a beginning writer is that it creates plenty of opportunities to teach other aspects of writing and grammar that may not become available when the amount of text produced is curtailed. Indeed, in the comments we cited above, the observer was able to teach writing as a result of providing the type of help (in this instance with typing) that removed constraints, even if temporarily, thus extending the writing. This extension, in turn, gives us a glimpse at what the student could really accomplish, providing a different view of the student's competence.

In sum, the children were able to do some text editing on-line and they collaborated more readily to complete a joint product successfully during the second-phase. These changes were as evident for the LEP as for the English-monolingual students, indicating that the teacher was being successful in helping both types of students perform similar tasks and at similar levels. Progress, however modest, was now becoming more evident. It continued into the last two months of the project, April and May, which we will now examine.

The Third Phase

For the last months of the project, the classroom computer activities required the children to compose text on the computer and to modify their drafts. What follows below are selected examples that trace the improvement of the children. These changes were not uniform; if anything they were characterized by uneveness. Children who seemed to be mastering the tasks gave the impression of not knowing what to do during the next session, and vice versa. The examples also show that children's writing must be understood in the context of the conditions that we create for them to learn.

Writing in this phase included letters and stories for the Computer Chronicles. The procedures followed in producing text varied considerably depending on the students. The first sample presented below is by two LEP girls, Francisca and Mercedes, using the Writer's Assistant text editor. This was the first time they had used a text editor and felt rather uneasy about what they were doing. They were entering text they had written previously with paper and pencil. They decided to take turns with one dictating what was on the copy and the other entering text. Rather than the continuous turn-taking which characterized their and other students' earlier collaborations (see Chapter 4 for details), they decided to exchange turns after a more prolonged period of time. This exchange was not without conflict and negotiations, as the following discussion illustrates.

> "Francisca starts dictating. Mercedes types. They have a paper and pencil copy. Francisca tells Mercedes, 'let me write it now,' and she moves over into Mercedes' chair to be in front of the keyboard. Both now share one seat... Francisca does not know how to spell 'Alberca' (swimming pool); Mercedes begins to spell it out and corrects Francisca...She begins to erase the sentence and the previous one; I ask her what she is doing and she stops. Mercedes again dictates the sentence that F erased and then exclaims that it is her turn. The girls switch seats. After the first sentence, Francisca says, 'ya es mi turn. Ya te toco un period.' ('It is my turn. You already wrote a period.') 'Mercedes responds, 'yo se, pero a ti te toco dos veces.' (I know, but you had two turns.')
>
> I ask the girls if this is the first week they use (the systems editor). Mercedes says yes; she also tells me that (two other girls) erased it all the other day because they were goofing around. The girls again switch seats. F says, 'Estamos escribiendo mucho, verdad?' ('We are writing a lot, right?') M keeps telling F to hurry. Francisca dictates but is not really paying attention to the screen in order to correct spelling, etc. For example, M types 'plalla' (beach) for 'playa.' I noticed that F has it spelled correctly in her paper but she does not correct M. The girls finish entering text. Now what? they ask me. I point to the top of the screen and tell them what to do next. We save the text by me telling them what to do and by pointing to where on the screen (the directions) appear."

Several other children followed the procedure of typing in text they had produced previously with paper and pencil. In most cases, with the children on line, the observer provides help with the writing process. The next writing sample is by Holly. As she was getting ready to write, time ran out because her partner took so long in entering her own story. Consequently, Holly returned during her lunch hour to enter her story.

> "During lunch break, Holly came in and asked BL if she could do her story now. BL says it is ok... I ask Holly if she wants me to type. She says yes because it will go faster... As Holly dictates, I ask questions to clarify the sentences. For example, Holly dictates, ´...and then he punched him.´ ´Who punched who?´ I asked. Holly then clarifies her sentence, ´Super Bunny punched the man down!´ We get ten lines and her story is finished . I tell her how she can save. She follows instructions fairly well and gets me a printout."

Rodolfo and Noe received similar help from the observer in writing a letter to their mothers. The observer took over the typing duties, leaving the children with the responsibility of composing the text collaboratively and in interaction with her. While the children were dictating the letter, the observer provided selective prompts to guide and clarify their writing.

The final example provided is by Michelle working alone. The observer gave her some initial help with the procedures on how to enter text using the systems editor and the rest was done by the student. This time the observer did not provide assistance with composing and the student typed the text in herself. Notice the spacing between letter and the frequent periods. Also note that she uses the English ´miss´ for the Spanish ´mis´ (my). Mistakes and typos notwithstanding, this student composed on-line and wrote for communication. In the process she produced sufficient text for the teacher to teach writing.

One value of observing children over time is that we learn that development, of writing in this case, is not linear and neat, but discontinuous and messy. Through prolonged observations we are also able to gather evidence of change that is easily missed with single observations, especially when the children are "hard to teach." Equally important, in situ observations reveal what it is about the way instruction is organized to facilitate or constraine children's progress. The examples presented above between assisted and unassisted writing suggest that help with typing and help with the actual writing process facilitate sound writing. This is no surprise. However, a teacher rarely has an observer in his or her classroom who is willing to help the children with their writing. Some of this help can be built into the software program, but that help, we found out, was rarely sufficient, especially for beginners.

This finding suggests that the teacher must use regular writing lessons to provide practice with the process of writing and grammar, while writing with the computer could become the central communication activity for the class. In an important sense, regular lessons must help create the conditions for the use of the computer. The lessons must function in lieu of an adult supervising the writing process on line. How to organize classroom lessons to provide the children with the social, linguistic, and intellectual support to take optimal advantage of what computers can offer is the greatest challenge facing computer-novice teachers.

Conclusion

We would summarize BL's experiences introducing a computer into her classroom in these terms: It was laborious and at times exasperating. The children's progress was slow, unveven and often hard to detect. The computer did retain the students' interest all year. Most children were eager to work with the machine and seemed to learn the necessary computer operations and do some writing.

It is clear to us that the mere presence of this new technology in a classroom will not produce major changes in instruction. The equipment is embedded in an instructional system; it is the system and not the machine that is responsible for change or maintenance of the status quo. Computers are no solution to difficult instructional problems and do not replace teachers. Given the current state of software distribution, LEP students may only be exposed to drill and practice activities. In addition to providing differential access to important educational resources along ethnic lines, this practice will further discourage the development of basic educational skills.

It is equally clear to us, however, that computers afford teachers a medium, a novel way, an opportunity, an excuse, if you will, to question the status quo. What is it about the ways we organize instruction that even the introduction of these wonderful machines has no visibly important effect on classroom organization?

BL's classroom, the characteristics of which we have described in previous chapters, presented formidable constraints to the "effective" use of the machine. These constraints, most of them systemic, such as classroom scheduling, curricular goals, books, and particular groupings of children, established the boundaries for action. They, at the risk of sounding too colloquial, define the nature of the game and much of how it can be played. BL´s first responsibility was to implement the curriculum in good faith. But she also had to think of how, without neglecting her teaching duties, to introduce the computer in ways that could help the children. Her situation is typical of most teachers. And under such circumstances the computer easily becomes an intruder whose potential benefits are outweighed by the inconveniences they create. The strategy of choice then becomes, not by design but by necessity, to accomodate the machine to the prevailing constraints. This decision, although pragmatic in the short-run, is absolutely fatal, especially for language minority students. It assumes, uncritically, that the status quo is the appropriate context for computer use. Invevitably, existing curricular practices become the "model" for computer use. Why should we expect that the same practices that have produced widespread academic failure will create propitious environments for computer use?

From our perspective, adapting computer use to prevailing educational practice (i.e., drill and practice for language minority students) has one immediate consequence: it reduces teaching with computers to computers teaching kids. The teacher then has no choice but to rely, indeed, trust the software. Little of what we have read, reviewed, or observed would suggest that such trust is well-placed. In fact, the consensus of the field seems to be that most educational software is less than helpful (Lesgold, 1983). Additionally, if certain children have problems with the software assigned, one of the teacher´s few options is to select simpler software, reduce the level of difficulty of the assignment, or, as is commonly done with reading and math, break up the assignment into small, discrete steps that the children must master before proceeding. Another common option is to decide that certain children, for example, limited English-speaking students, are simply not ready for computer work, at least not at the level of other, more advanced (English fluent) students. As mentioned in the introduction to this chapter, computer work in schools, despite the newness of the innovation, is already characterized by such stratifying practices. This fact should not surprise us, it reflects broader, long-standing curricular practices which are the norm in most schools.

What can we offer besides warnings about reductionism and tracking? Fortunately, we do have many positive examples of computer use with a variety of children and situations. From our experience two key principles emerged and both highlight the importance of the social context of computer use. One is the need to subordinate computer work to a higher order goal. We were particularly successful when communication with other people was the goal of writing activities, that is, when the task being done had a real purpose that made sense to the students. Another is the coordination of resources around a common goal. We were impressed with the students' use of social support from a number of sources to accomplish their computer tasks; written support or help from a single source was rarely sufficient.

All classrooms are social environments purposely organized to achieve social and intellectual goals. As such, classrooms are not "natural environments," they are "artificial" or socially created entities. Our findings indicate that specific classroom practices mediate the way that computers are used. They help define the nature of computer activities.

This sounds obvious, but it is important, because it challenges the popular notion that computers are "general purpose" tools adaptable to a wide range of classroom conditions. This adaptation notion is problematic, for reasons we emphasized earlier. If classrooms are social creations, then they can be socially re-created or re-constituted in fundamentally new ways. Therein lies the importance of computers in classrooms, not necessarily in providing new technological solutions, but in making visible how much our social arrangements constraint children's thinking; in providing new reasons to question the instructional conditions under which we ask children to learn.

CHAPTER 8:

TEACHING PROBLEM SOLVING STRATEGIES

Marti tum Suden and Robert Rowe

We wish to thank Steve Black, Nick Maroules, and Randall Souviney for their comments on this chapter.

Computer programming is one of the most prevalent instructional uses of microcomputers in schools (Becker, 1983; Boruta et al, 1983). Programming is often emphasized because it is presumed to have a positive influence on higher order thinking (Papert, 1980) and because it contributes to "computer literacy" (Luehrman, 1980).Learning to program a computer is said to develop conceptually clear thinking because programming requires precise expression, planning, rigorous thinking, and the manipulation of explicit statements in the generation and testing of hypotheses. Therefore, as students learn to program, they presumably learn about problem solving processes. Once students learn to solve computer programming problems, they presumably will be able to transfer their problem solving knowledge to other domains.

The belief that learning to program a computer improves problem solving is the most recent instantiation of the belief that rigorous disciplines such as logic, geometry or Latin "exercise the mind" and enhance higher order thinking (Pea and Kurland, 1984). It was this line of thinking that led to the development of the LOGO programming language as a microworld or learning environment for children. Papert (1980) claims that children who learn to explicitly teach the computer to do something learn more about their own thinking.

LOGO is a growing family of computer languages. The language is interpretive, which means it can be used interactively. This design feature provides early and easy entry routes into programming for beginners who have no prior mathematical knowledge. This ease of entry is facilitated by "Turtles," concrete and manipulatable objects (cursors on a computer screen, robots on the floor) which carry out instructions in very visible ways. Characteristic features of the LOGO family of languages include procedural definition with local variables that permit recursion. Thus, in LOGO, it is possible to define new commands and functions which then can be used exactly like primitive ones.

Papert accompanies his belief in computer programming as a learning environment in which children will enhance thinking powers and transfer their rigorous thinking from one domain to another with a philosophy of education. Central to this philosophy is his belief in self-guided "discovery learning." He maintains that students can learn to program without an explicit curriculum and without direct instruction from teachers. The LOGO programming language is so powerful that students are led to discoveries about its internal structure and become aware of their thinking without a specific sequence of curricular steps. In support of his claims, Papert and his colleagues (1979) provide examples of children "spontaneously" discovering the effect of varying numerical inputs, breaking problems into parts, combining sub routines into procedures or superprocedures, which provide support for the idea that students learn general problem solving skills by learning to program.

The power of LOGO and the persuasiveness of Papert's claims have led researchers outside the MIT LOGO group to investigate more systematically whether learning to program promotes the development of problem solving skills and whether people are able to transfer their problem solving knowledge to other domains. Pea and Kurland (1984) compared the activities of several groups of students, some of whom had participated in LOGO programming courses, on tasks that required planning. One task required the students to organize the most efficient plan for completing a set of classroom chores, such as watering plants, putting away chairs, cleaning chalkboards. The second task included a microcomputer program that enabled students working with the experimenter to design and check their plans interactively and a graphics interface that enabled the students to see the plans enacted in a realistic representation of the classroom.

Pea and Kurland found that students who had one year of programming did not differ from same-age controls who had not learned to program on various developmental comparisons of the effectiveness of their plans or their processes of planning. Students who had learned to program neither used the cognitive skills alleged to be developed in LOGO to organize a more efficient chore-completion routine, nor made better use of available feedback aids provided in the planning environment. They conclude that there does not seem to be any automatic improvement of planning skills from learning LOGO programming.

They considered various explanations for their findings. After dismissing potential objections to the inappropriateness of their planning tasks, they considered LOGO itself. They report problems with the LOGO programming environment as a vehicle for learning. The LOGO "discovery learning" pedagogy is insufficient, they feel, for the development of generalizable planning skills. This is really a complaint against the "learning without curriculum" approach that Papert advocates. From their perspective, learning how to plan is not intrinsically guaranteed by the LOGO programming environment. It must receive support from a structured context, including teachers (who, tacitly or explicitly, foster the development of planning skills), examples, models, student projects and direct instruction.

Their findings are consistent with other studies examining transfer of cognitive skills from one domain to another. It is notoriously difficult for people to spontaneously recognize the connection between problem isomorphs-- problems of identical logical structure but with different surface forms-- and to apply problem solving strategies learned in one context to another context (Wason and Johnson-Laird, 1972; Gick and Holyoak, 1980; LCHC, 1983; D'Andrade, 1984). It is clear that the similarity of the training task and the target task is not, in and of itself, sufficient to induce spontaneous transfer.

When transfer does occur, it seems to be when certain environmental conditions are in place. Naming the problem solving situations, providing direct instruction and practice, labelling the strategies, explicitly stating the relationships between two problems are some verbal mechanisms that can induce transfer (LCHC, 1983: 339). While transfer can be induced by explicit verbal instruction, it can not be said that transfer is occurring spontaneously. An overwhelming amount of our daily life is routine. We perform the same actions, in the same order, day after day. We have seen the same "problems" many times before. When we repeat the "solution" to these problems day after day, the connection between problem and solution becomes deeply ingrained. The problem of transfer is minimized, often dissolved entirely, when similar problems are repeated over and over (Lave, 1979).

In sum, special circumstances seem to be needed in order to facilitate transfer: (1) intense and systematic instruction on problem solving strategies, (2) the transfer situation needs to be so much like the learning situation that people do not even notice that they are transporting knowledge from one situation to another, (3) the similarity between the transfer and learning situation is marked, labelled or formulated.

Arranging a Classroom Environment for Teaching Problem Solving

Rowe arranged the learning environment in his classroom so that these conditions favorable for transfer were present. He engaged in the direct instruction of problem solving through a curriculum dubbed "the Problem of the Week" (to be explained below). He gave his students systematic and repeated practice in the use of problem solving strategies. He arranged two problem solving environments that had many surface features in common, one within the regular classroom and one within the LOGO lab. He provided verbal labels and formulations of the problem solving apparatus for students' use.

In this section, we describe (1) the approach to problem solving that Rowe taught his students (2) the manifest and redundant cues he provided his students so that they would recognize the situation in which problem solving strategies were to be applied and (3) the teaching/learning situation in the LOGO lab.

The General Problem Solving Plan

Rowe provided direct instruction in the approach to problem solving taken by Polya (1957), Souviney (1981), Charles and Lester (1982), among others, stressing a framework within which students can develop and use the specific skills and strategies needed to solve problems efficiently.

Polya (1957) specified a heuristic designed to pinpoint the learning process behind intuitions regarding problem solving. He proposed that certain kinds of problems can be attacked by applying a sequence involving four steps:

1. understanding the problem
2. devising a plan by choosing a problem solving strategy
3. carrying out the plan to find a solution to the problem
4. testing and generalizing the problem solution

In short, this approach identifies a small set of standard guidelines and suggests that the guidelines can be applied as strategies to solve problems effectively.

Marking Problem Solving Time

In order to teach students problem solving strategies, Rowe established a classroom atmosphere where problem solving became a daily routine. Students were immersed into this environment by a number of procedures which the teacher instituted and employed on a regular basis.

Establishing a regular time for problem solving. Rowe set aside a portion of each school day for problem solving. This time was called "The Problem of the Week." This period of the school day was explicitly marked, both in writing and verbally. The period of the day devoted to the "Problem of the Week" was posted on the classroom schedule along with language arts, social studies and other curricular topics. Thus, students were encouraged to see problem solving as a curricular topic equal to other subjects. The Problem of the Week was formulated at the beginning of the instructional period. The posted time was reinforced verbally: "OK kids, get ready for the problem of the week", or "get ready for problem solving time."

Visual reminders. The verbal formulations of the problem solving routine were reinforced by information posted around the room. One bulletin board in particular was devoted to problem solving. Posted on it were the steps in the problem solving routine and suggestions about the strategies to be used when attempting to solve problems. The bulletin board served as a visual reminder of the problem solving strategies being taught.

Explicating the Problem Solving Routine. The teacher presented problem solving lessons to the class as a whole, discussing the various skills one would use to solve the problem with the students. After a discussion of the problem solving activity, the students worked on the assignment alone or together with other students. The students were allowed to move around the room when forming work groups.

Teaching Problem Solving with LOGO

In addition to teaching a 6th grade class, Robert Rowe was responsible for the school's computer lab which was in the room adjacent to his classroom. When he took his sixth graders to the computer lab, he used LOGO as an environment in which students were to apply the problem solving strategies that they had learned in the classroom. This was a reversal of the relationship between programming and problem solving. Students are generally taught the LOGO programming language and are expected to develop problem solving skills from this experience that can be transfered to new environments. Rowe taught his students problem solving in the problem of the week curriculum, and used LOGO as the transfer environment.

Rowe's decision to use LOGO as a problem solving environment came from his dissatisfaction with the conventional way of teaching LOGO. He wanted to test a different approach. The conventional approach, as found in Papert (1980) and Papert et al (1979), is additive or what Levin (personal communication) calls "compositional." Students are introduced to fundamental commands, such as FORWARD, RIGHT, LEFT. As they master these simple commands, they are introduced to more complicated ones, e. g., REPEAT, EDIT MODE, VARIABLES, which they add to the elementary commands in a building block fashion. When a sufficient number of elementary commands have been mastered, students are able to construct geometric shapes such as boxes, triangles or houses. After the construction of geometric shapes has been mastered, students are moved on to more sophisticated matters, such as sub-routines and superprocedures, editing and debugging, control of continuous processes with loops, variables, conditions, stop routines, and recursion.

The different approach that Rowe wanted to implement is holistic and what Levin calls "decompositional." Instead of having students begin with small building blocks and compose a final product from the elements, the holistic approach presents students with a complete entity and asks them to explore, manipulate, analyze and modify it.

In order to compare the compositional and decompositional approaches to LOGO, Rowe divided his class into two groups for instruction in the computer lab. Students were assigned to the groups primarily for pedagogical purposes which influenced random sampling. Students were split up according to schedules restricted by band, their prior LOGO/computer experience, and any district classification. For example, if four students were classified as GATE, two each were randomly put into "Group A" (which was taught using the decompositional approach to LOGO) and two each were assigned to "Group B" (which was taught using the compositional approach to LOGO). If eight students were brand new to LOGO, four girls and four boys, then two girls and two boys were assigned to each of the two groups.

Learning the Basics. After pretests (to be explained below) were administered, the students were divided into the compositional and decompositional groups (described above) for instruction in the computer lab. Rowe then spent six weeks teaching the basics of computer literacy and LOGO programming.

Group A and Group B were taught the same material but at different times and with a different emphasis. Rowe presented the students with instruction in three sections: (1) basic information, (2) an activity to be modeled or recreated and (3) a self directed activity. The first section introduced the students to basic LOGO commands -- e.g., DRAW, FORWARD (FD), GOODBYE. The students were expected to familiarize themselves with these commands by attempting to use them. The second section presented an activity e. g., a drawing or commands plus a drawing which the students attempted to recreate. The third section challenged the students to attempt a more complex design drawn on a worksheet.

The instruction surrounding the presentation of this information was similar except for a subtle emphasis on strategy. Group A (the "decompositional group") continued to receive explicit instructions emphasizing the problem solving strategies taught in the classroom to all students. When queried by students in Group A, the teacher suggested using the basic information (commands) as a strategy. The students were encouraged to take a given command and look for ways to apply it to the drawing or relate it to other commands in order to recreate the drawing in section two. The "compositional" group, Group B, was instructed according to the discovery learning approach recommended by Papert (1980). This group received suggestions to use the commands to build up a copy of the object they were presented.

The students in Group B were encouraged to compose a drawing out of the essential building blocks while the Group A students were encouraged to identify the building blocks within the drawing and look for relationships between the blocks before attempting to recreate the drawing. After students worked on worksheets to become familar with LOGO commands, they began working on projects. The presentation of each new project allowed the teacher to re-emphasize the teaching technique for each group.

Measuring Student Performance.

Several assessments of the student's problem solving abilities were made for the problem of the week domain and the LOGO domain. Pretests were administered in October and posttests were administered in June.

The Heath Test. We used six problems from the Heath Math Program to measure students' learning and transfer of problem solving strategies in the problem of the week domain. The problems and the type of strategy they tested are:

(1) "The Line Up" is a permutation problem
(2) "Tangle of Triangles" is a visualization problem
(3) "A Raft of Rectangles" is a combinations problem
(4) "The Staircase Case" is a math operations problem
(5) "A Balancing Act" is a process problem
(6) "Don't Fence Me In" is a math operations problem

The LOGO domain was assessed by two tests: one specifically calling upon LOGO knowledge, the "LOGO Knowledge Test", and the other requiring the student to demonstrate and use more general mathematical knowledge (the Brookline Test).

The LOGO Knowledge Test consisted of six problems designed by the classroom teacher to test the students' knowledge of LOGO and its environment. Problems one and two required visualization and translation between a given shape and the commands to produce it and vice versa. Problems three, four and five required visualization of spatial relationships. Problem six required remembering specific LOGO commands.

The Brookline Test (Papert et al., 1979) measured students' understanding of background math knowledge assumed to be necessary for programming in LOGO. The test consisted of four problems. Problems one and two were visualization problems requiring estimations of line length and angle size. The third problem required translating directional moves into math operations. The fourth problem involved planning how to get from one point to another - a process problem. Thus, three of the five problem solving categories are represented in this test.

Problem Solving Notebooks. Students recorded their problem solving work in notebooks. As might be expected from thirty six 6th graders, not every problem introduced to the class found its way into every student notebook. The problems on which we managed to collect complete data fell into the following categories:

1. combinations--e.g., problems where order is not important
2. permutations--e.g., problems where order is important
3. visualization--e.g., problems using symmetry
4. math operations--e.g., additive problem isomorph
5. process--e.g., problems where the optimum strategy is important

Scoring the Problems. The students' work on the problem solving tests and in their notebooks was scored based on the steps of Polya's heuristic discussed earlier.

1. understanding the problem by being able to state the goal and conditions expressed in the problem statement.

2. devising a plan by choosing a strategy for solving the problem.

3. carrying out the plan to obtain an answer.

4. evaluating the answer.

Each step was scored from zero to two points, for a total of eight points on any problem. We were interested equally in the answer that students obtained and the process by which they arrived at their answers.

We examined the data for indications of change over time in the students' ability to apply the problem solving heuristic as evidenced by their ability to concretely state their goals, conditions and strategies. It was expected that increased facility at explicitly stating such information would lead to a more systematic and complete demonstration of the work done to obtain an answer.

Rowe's teaching arrangement, in which he taught problem solving in his classroom and in his computer lab, enabled us to make a number of observations about the effectiveness of explicitly teaching problem solving strategies to students. First, we compared the students' acquisition and use of problem solving strategies within the problem of the week domain. Here the issue was whether students learned the problem solving strategies and applied them with increasing skill to the new problems that were presented to them each week. Second, we examined students' acquisition of LOGO knowledge and more general skill within the LOGO domain. Third, we examined students' performance in the computer lab. Here we compared students who were taught LOGO by the decompositional approach and the students who were taught LOGO using the compositional approach. This difference in instruction was expected to effect student performance on the two tests. The compositional group (Group A) was expected to perform better on the Brookline test because it tested more general problem solving skills, and the decompositional group (Group B) was expected to perform better on the LOGO test because it tested basic programming knowledge.

Results

The Development and Transfer of Problem Solving Strategies

The problem solving curriculum conducted within the classroom consisted of problems which required the use of different problem solving strategies and had varying degrees of difficulty. The students were given one problem solving period of 20-30 minutes to work on each problem from the Heath Pretest. The teacher collected the worksheets at the end of a period and returned them to the students the next day. Evidently, some students did not turn in their worksheets at the end of a period and could not find them at the beginning of the next period. The teacher gave these students a new worksheet; however, this situation left us with incomplete data in some cases.

The Wilcoxin test (Siegel, 1956) was used to test the null hypothesis, i. e., that there would be no change in performance on these problems due to the explicit teaching of problem solving strategies during the school year. The results of this test indicate that we may reject the null hypothesis for five of the six problems at $\alpha < .01$. On all problems except the visualization problem (#2) the students showed significant change in performance during the school year. The surface features of this problem appear to have created confusion for the students who did not score well on either the pre or post test.

Table 19

Students' Performance on Heath Pre and Post Tests

Test Question

	#1		#2		#3		#4		#5		#6	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
N =	33	23	33	23	31	22	31	23	25	24	25	24
Median =	2	3	2	3	2	5.5	2	4	0	4.5	0	.5
Gain =		+1		+1		+3.5		+2		+4.5		+.5

The other problem that was difficult to interpret was a math operations problem (#6) involving the relationship between perimeter and area. The students did not recognize a way to approach this problem and many wrote on their papers "I don't understand" or "I don't know how to do this," even at the end of the school year. Eight of the sixteen students were unable or unwilling to attempt this problem on both the pre- and posttest. Seven of the other eight students who attempted the problem on the posttest did not do so on the pretest. The eighth student attempted the problem but had no real understanding of it. Despite these peculiarities in the scoring system, the Wilcoxin test indicates that the gains made by these eight students were statistically significant ($\alpha = .01$).

We also selected two sets of problems from the problem of the week curriculum to measure students' learning of problem solving strategies. The problems we chose were problem isomorphs, that is: they had the same logical structure but had a different surface form (i.e., wording). The problem isomorphs we will discuss here are: (1) the process isomorph and (2) the commutative isomorph.

Process Isomorph. The process problems presented students with eight objects (baseballs in one and eggs in the other), all similar in appearance, and asked them to find the lighter or heavier object in only two weighings using a pan balance. The baseball problem was presented in October and June and the egg problem was presented in March.

Table 20

Students' Performance on Process Isoporph Problems

	Problem		
	BB (Oct)	Egg (March)	BB (Jun)
N =	25	20	24
Median =	0	5	5
Gain =		x= +5	y = +5

key: x = October to March y = Oct to June

The students showed significant growth in their ability to do this type of problem during the school year. There was significant improvement by the entire class from October to March and October to June [Wilcoxin (α=.02)].

Commutative Isomorph. The commutative problems embed an algebraic principle into the problem. The commutative principle (a+b=b+a) represents an abstraction of a mathematical concept which students find in math word problems and drills of math facts.

Our analysis focused on the "water fountain" problem and the "gold digger" problem. The water fountain problem, which made its appearance in November, asked the students to measure 6 liters of water from a fountain using only two cans of 7 liters and 11 liters. The goal was to arrange a set of measurements which would produce the desired amount of water in one of the larger cans. The gold digger problem, done in February, asked the students to identify the weight of various gold nuggets using a pan balance and three weights of known amounts: 1, 3 and 9 grams. The goal of this problem was to arrange a set of measurements which would enable a number of gold nuggets of unknown quantity to be weighed up to the maximum amount possible (13 grams).

Table 21

Students´ Performance on Commutative Problem

	Problem Name	
	Water Fountain	Gold Digger
Month Given	Nov	Feb
N	14	20
Median	5	5
Gain =		+0

While the median score remains the same, students´ performances appear to increase from the water fountain to the gold digger problem; however, the sketchiness of this data does not yield results which are statistically significant.

It is interesting to note that only two of the twelve students showed any performance loss, and this loss was minimal (-1 gain score). One student's performance is especially interesting because it highlights the fragility of the learning process which teachers must support. This particular student arrived at the correct answer for the water fountain problem but, followed an inefficient, circuitous route indicating incomplete understanding of the optimum strategy. Later, when attacking the gold digger problem, this student used the optimum strategy. She did not get credit for the correct answer, however, because two of the measurements are left off her worksheet which produced the small performance loss.

In sum, these improvements make us optimistic that the direct instruction of problem solving strategies is responsible for students' learning and the transfer of this knowledge to new situations. However, we must remain cautious. The complexity of data drawn from a naturally occurring setting must temper enthusiasm for this interpretation.

Developing LOGO Knowledge

LOGO Problem Solving. Students showed improvement on three of the four Brookline test problems from the pre to the posttest. The students' median performance improved on all problems but one. The Wilcoxin test allows us to reject the null hypothesis for 3 of the 4 problems ($\alpha < .05$, .05 and .02). However, this fourth problem contained sixteen of the thirty-four possible points. Therefore, while students' performance was in the predicted direction, it is not surprising that the results are not statistically significant.

Table 22

Students' Performance on Brookline Test

Test Question

	#1		#2		#3		#4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
N =	34	30	34	30	34	27	34	29
Median =	9	9.5	4.0	3.5	4	5	1	1.5
Gain =		+.5		-.5		+1		+.5

The math operations problem (#3) was given closer analysis because it is similar to the water fountain and gold digger problems. This problem asked the student to translate a series of forward and backward steps into a one directional step.

To solve this problem, the students need to link forward steps to backward steps—i.e., forward steps require addition and backward ones subtraction. Once they perceive this relationship, carrying out the actual process and reordering of information to arrive at the correct answer was quite elementary for most of these students. In fact, ten of the twenty five students scored the maximum points possible on both the pre and posttest. The students showed significant growth over the school year [Wilcoxin (α=.05)].

LOGO Knolwedge. The results of the LOGO test indicate that the students' knowledge of LOGO increased from the beginning of instruction to the end on both the overall test and each of the six individual problems.

The median score of the class as a whole gained 12 points from November to June.

Table 23

Students' Performance on LOGO Knowledge Test

Test Question

	1		2		3		4		5		6	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
N=	32	29	32	29	31	29	31	29	31	29	31	29
Median =	2	4	2	4	1	4	1	4	0	3	0	1
Gain		+2		+2		+3		+3		+3		+1

Compositional and Decompositional Approaches to Problem Solving

To determine whether students who were taught LOGO emphasizing the discovery learning approach (compositional group) differed from students who were taught emphasizing problem solving strategies (decompositional group), the performance of Group A and Group B on the Brookline and LOGO Knowledge Tests were compared.

LOGO Knowledge. We expected Group B to perform better than Group A on the LOGO Knowledge Test because it assessed specific LOGO skills which were a part of that group's explicit instruction. The results were in the predicted direction. Group B gained 12.5 points on the LOGO test while group A improved 11 points. The results obtained by Group A on this test deserve further comment. They made an improvement which was greater than expected. This improvement suggests that students can learn specific LOGO commands when programming information is embedded within a broader framework of students' instruction.

Table 24

The Performance of Group A and Group B on the LOGO Knowledge Test

	Group A		Group B	
	Pre	Post	Pre	Post
N =	15	16	16	13
Median =	5	16	6.5	19
Gain =		+11		+12.5

LOGO Problem Solving. We expected Group A to show more change than Group B on the Brookline test because this test assesses students' application of problem solving strategies. The results were in the predicted direction; Group A increased by 3 points while Group B showed no gain. While this difference was not statistically significant, the results suggest that Group A students transfered their problem solving skills from the classroom to the LOGO lab.

Table 25

Group A and Group B Performance on Brookline Test

	Group A		Group B	
	Pre	Post	Pre	Post
N=	17	15	17	11
Median =	19	22	18	18
Gain =		+3		+0

Students' Work While Solving Problems. The idea that students would transfer an understanding of the problem solving heuristic from the problem of the week curriculum to the LOGO tasks also receives support from anecdotal evidence about students' work while solving problems. One piece of evidence relates to the students LOGO notebooks. The two groups began a series of projects which were to be planned and recorded in their notebooks. Although neither group of students was totally successful in its planning or record keeping, some differences were observed.

The students were encouraged to write down the commands, procedures and routines they were trying to use in their projects. This information was then tried out using the DRAW mode of LOGO. If the visualized pattern did not match the turtle drawn pattern, then the student was to make changes and adjustments before storing the information permanently on disk. Group A students tended to "outline" their projects by nesting procedures within procedures. Using this approach the students first decided on the main procedures, then moved inside one such procedure and worked on its subprocedures. This organization was extremely productive for pairs of students who cooperated well with one another. After the initial planning, they divided up the work in various ways and used their computer time efficiently.

Group B students tended to use their notebooks merely as a record keeping device after trying out an idea on the computer in the DRAW mode. If the attempt was suitable, a procedure might be defined; if the attempt was unsuitable, the students continued drawing and recording their moves until the screen version was suitable. One pitfall frequently encountered using this method was inefficient visual to spatial translation of images — e.g., overdrawing or underdrawing. Students compensated for such errors by moving forward or backward as needed or changing the angle by increasing or decreasing the size of the image. Even though they recorded these movements in their notebooks, few students recognized the math operations--addition or subtraction--embedded in these moves. As a result, they rarely recombined the several moves into only one move. Most frequently, when ready to transfer their notebook notations into a defined procedure, the students copied the information without making any changes. As students became facile with the DRAW mode and translating their visual images into spatial commands, they tended not to record on paper at all, allowing the computer to do this work. In effect, this served to block their ability to see the relationship between commands or to utilize any problem solving strategy other than trial and error.

This informal assessment of students' work while in the process of solving problems suggests that the compositional approach neither helped students develop efficient and systematic planning techniques nor invited them to transfer the paper and pencil strategies learned as part of the classroom problem solving curriculum.

Conclusions

The work in this chapter was addressed to the following questions:

(1) Does the direct instruction of problem solving strategies lead to improved problem solving by students?

(2) Do problem solving strategies transfer between situations when the environments are closely matched and the use of the problem solving strategies has been verbally marked and formulated?

(3) Do students who have been taught a programming language (LOGO) using a decompositional approach use problem solving strategies better than students taught this same language using a compositional approach?

Based on test results, we feel comfortable concluding that students who receive intensive and systematic instruction in problem solving and have the problem solving apparatus formulated for them explicitly can learn problem solving strategies and transfer them to new problems that have a similar logical structure with varying surface features.

We are also encouraged by our results concerning the utility of the decompositional and compositional approaches to teaching a programming language. The students who were taught LOGO by the decompositional approach did better than students who were taught using the compositional approach on a general problem solving test, while students who were taught LOGO by the compositional approach did better than students taught by the decompositional approach on a test of LOGO knowledge. Both of these test results are in the direction predicted by the assumptions underlying the compositional and decompositional approaches. Students taught by the decompositional approach seemed to approach programming problems differently than the students taught the compositional way. The decompositional group planned their products in advance while the compositional group treated their notebooks as record-keeping devices after they completed their work.

Implications for Further Study.

It is best to view this work as a pilot study. Our intuitions about the way to study problem solving in naturally occurring situations need refinement before solid conclusions can be drawn. While we will want to make changes in research design and data gathering in future studies, we will want to keep the problem solving activity itself in the naturally occurring context of the classroom for a variety of reasons. The most notable reason is that we want to be able to test the generality of the problem solving heuristic.

The appeal of the problem solving heuristic is that it may be applicable to diverse situations which go far beyond classroom math problems and computer projects which provide the data for this research. Such a framework to learning assumes that our task as educators is broader than the transmission of specific knowledge, even when that knowledge involves abstract concepts. Rather, the task involves critical thinking and abstracting generalizable relationships from specific knowledge.

Dynamic Support for Problem Solving. Teaching problem solving to children requires a rich, supportive environment. In the conventional approach to teaching a problem solving task such as LOGO, all the parts are available, but the sense of the whole and instructions for putting the parts together are often missing. The decompositional approach to LOGO adopted here provided an alternative form of supporting the students' learning. In a decompositional approach to problem solving, teachers present the entire task to the students and provide the expertise to accomplish the task with decreasing amounts of support.

The "nominal" task is located on several planes. The teacher has a learning activity which represents part of a pedagogical class of activities. The students also engage in the learning activity; however, for them the task is more specific or concrete--i.e., a set of behaviors.

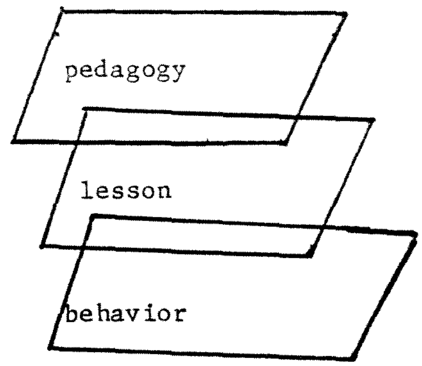

Figure 14: Planes of Pedagogical Activity

The promise of the decompositional approach to teaching the problem solving heuristic lies in the fact that it can help us capture ethnographically the thread which links all three planes of activity. By looking at both the teacher's performance and the students' performances, we trace the thread of underlying competence as it moves from the intersubjective plane (Teacher -Student interaction) into the intrasubjective plane (Students' reflexive interaction).

<u>Collecting process data.</u> The use of field notes to collect data about how students approach problems was problematic since the ethnographer could not capture everyone's ideas simultaneously. Attempts to videotape students describing their problem solving process were problematic for the same reason. In future research, we plan to have the students write in their problem solving notebooks about the process they were going through. Such a writing activity could be integrated into the language arts curriculum of the classroom. In fact, a computer generated file could be used to support the note taking activity, thereby broadening the set of computer related skills learned by the students to include word processing (Souviney, personal communication). The "self report" data would facilitate access to the

problem solving processes and students' commentary on their thinking.

Constraining the Problem Solving Domain. Problem solving research can be approached by attending to two process factors: (1) the difficulty of the problem and (2) underlying problem isomorphs. The usefulness of these two factors is that they allow the researcher to trace changes in individuals and classrooms across time.

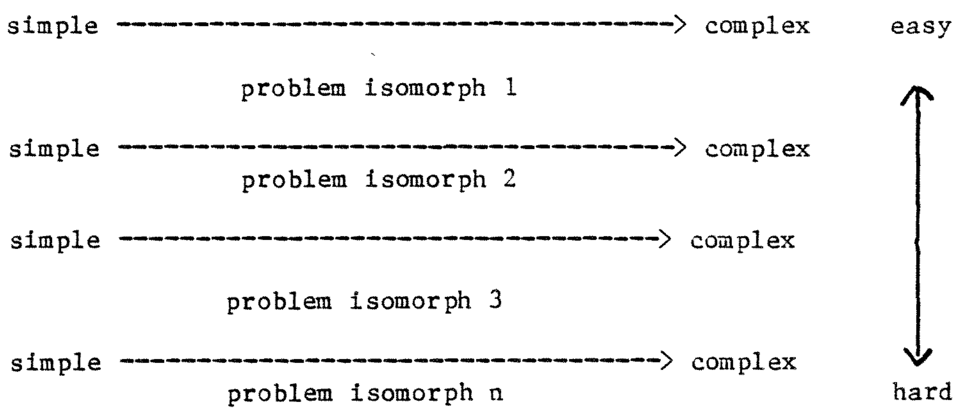

Figure 15: The Dimensions of Problem Isomorphs

The application of this rationale makes the research quasi-experimental within the natural setting and provides a set of expectations (loosely akin to hypotheses) of what will emerge from the ethnographic data. Explicitly teaching the problem solving heuristic (e. g., procedures for being systematic and complete, and concepts such as efficiency and symmetry coupled with feedback to the students on their attempts) can provide an environment where the learning of specific problem solving skills and their transfer to novel situations can be investigated. Learning to abstract information from a given situation and recognize new situations where that information applies represents a "metacognitive" skill which many people think is important our complex technological world. Discovering motivating and relevant ways to provide this type of education for students remains an ongoing concern for educational research.

We feel that further study requires careful staggering of the problem types in order to assess change. Thus, we would organize a rotation for the problems--e.g.,

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
type	1	2	3	4	5	1	2	3	4

With the focus on a specific problem type, there would be explicit instruction on the optimum strategy for that problem. This would provide the environmental support for learning these strategies and make them available for trasnfer to new situations.

Another approach would be to provide a curriculum which approaches all of these problem categories at the same time but varies each on level of difficulty. Presently tum Suden is attempting to integrate these two features (the problem isomorphs and the staggering of problem types) through a computerized individual instruction program in an after school setting. This current work allows the student freedom to chose the problem thereby enabling students to gain control over their work. In this approach to teaching and studying problem solving, once a problem is selected, the student shows mastery of the optimum strategy before moving onto a more complex isomorph in that problem category. The computer's ability to save work on disks allows students to review their work when approaching a problem in more than one session. We would use this information to supplement the information we gather from the problem solving notebooks.

CHAPTER 9:

SUMMARY AND CONCLUSIONS

Hugh Mehan, Luis Moll and Margaret M. Riel

We see three main problems with the current uses of microcomputers in education: (1) the educational potential of microcomputers is underutilized by the current emphasis upon programming and computer aided instruction (2) access to advanced uses of microcomputers is stratified; low income and linguistic minority students do not receive instruction which is equivalent to their middle income and linguistic majority contemporaries; and (3) an undue emphasis on computer programming in computer literacy curricula is ill preparing students for the world of work in an information society.

Our modest approach to addressing these issues has been directed toward exploiting a wider range of the microcomputer's capabilities with a diverse population of elementary school students through collaboration between elementry school teachers and university researchers. We are trying to make changes and improvements in schooling by teacher-researcher collaboration because teachers are in the closest contact with students and computers. This particular collaboration involved the systematic introduction of computer curricula in four classrooms accompanied by supporting knowledge and training. The computer curriculum, implemented in language arts and mathematics, was an extension of previous work conducted at UCSD to teach basic skills to small groups of special education students in resource rooms and after school clubs (LCHC, 1982; Riel, 1983; Levin et al, 1984). In this research project, we extended these educational efforts to a more diverse population of students, to the constraints of a regular classroom configuration and standard educational curricula.

The classrooms had diverse student populations in terms of age, measured ability, socioeconomic background and ethnicity. The students were in grades 2-6; their ability was measured from the lowest CTBS quartile to qualification for the GATE program. One classroom was part of a designated bilingual program, two others had a number of students who spoke Spanish as a first language and one was designated as a Chapter 1 classroom.

Mutual Influences Between Microcomputers and Classroom Organization

We wanted to know whether teachers use time and space differently and make modifications in what they teach and how they teach as a result of having a microcomputer available for instruction.

Impact on Spatial and Temporal Arrangements

There was no significant change in the way in which the teachers arranged the space and used time in their classrooms when they had a microcomputer available for instruction on a full time basis. The teachers who had used learning centers extensively in previous years used this spatial and instructional configuration when a microcomputer was made available to them by our project. The teachers who used whole group methods of instruction in previous years continued to teach their classses in this manner when the project made a microcomputer available for their use.

The absence of changes in temporal and spatial arrangements observed when microcomputers were introduced into classrooms shows how resilient classrooms are to attempts to change (Sarason, 1982; Cuban, 1983). If the results of this modest investigation are replicated in other school settings, we should not be surprised if microcomputers continue to be inserted into existing classroom arrangements (Michaels, 1984) and do not lead to wholesale changes in classroom organization.

While the introduction of a microcomputer for the purposes of instruction did not modify existing spatial and temporal arrangements in the four project classrooms, the availability of a microcomputer added a new dimension of participation to the classrooms. Each of the teachers in this project decided to have two students work at the computer at one time.

Dyadic peer interaction was the new "structure of participation" (Philips, 1982) that emerged when two students were placed together to work at the computer. Students were given assignments for work sessions at the computer by the teacher, either verbally at a whole-group orienting session, or in writing at the computer center itself. Students worked together on the assigned activity carrying out the teacher's assignments without direct adult supervision. When they had difficulty with computer operations, they often called to the teacher for help. However, the teachers' response was to encourage the students to use each other as resources, consult the written instructions around the computer, or to go to other students for assistance.

The teachers did not dictate a particular form of interaction to the student pairs. They were left to their own devices to sort out the manner in which the task would be completed. In that sense, the students' participation in the computer activity was voluntary, not compulsary. While they were responsible for completing their assigned session at the computer, the details of how that session would be completed was left to the students. Since the teacher did not monitor the students at the computer directly, their work was not evaluated moment-to-moment or publically, as it so often is in regular classroom lessons (Mehan, 1979).

As a consequence of this additional participation structure, students developed a different sense of social relations. The students assisted each other at the computer in ways that were productive. They often corrected each other's mistakes and cooperated in the completion of assigned tasks. Dyadic peer interaction also provided social resources which facilitated learning. In language arts activities, even when neither student began an assignment with an idea of what to do, the discussion of the problem often presented the students with the way to proceed. In the process of entering text, the student who was typing was often concerned with such local issues as the spelling of a word, while the other student concentrated on more global issues such as the construction of the essay and coherence among sentences.

Impact on Curriculum

The Computer as a New Means to Meet Previously Established Curricular Ends. Three of the teachers entered the project approaching Language Arts instruction from a perspective that integrates the teaching of reading with the teaching of writing. By emphasizing the writing process (Cooper and Odell, 1978), these teachers used the text that students wrote to create opportunities for students to read. In turn, texts that students wrote became a basis for later reading.

The computers were thoroughly incorporated into the instructional plan of the language arts curriculum. The teachers planned for computer activities in the same manner that they planned for other instructional activities. The computer was not an isolated piece of educational technology that students were taught about. It was a functioning part of the classroom environment and was used as frequently and in the same way as tables, chairs, typewriters, tape recorders, paper, pencils, chalk and chalkboard.

The teachers organized tasks for the microcomputer that were coordinated with tasks that were carried out in other parts of the curriculum. Reading and writing activities that were taught using paper, pencils and chalkboards were coordinated with activities that were taught using the microcomputer. A poetry writing activity begun with paper and pencil, for example, was extended to the computer center where a similar writing activity took place. In this role in the language arts curriculum, the microcomputer was a new _means_ to meet previously established educational goals.

The Computer as a Means to Meet New Curricular Goals. The availability of a microcomputer facilitated a new social organization for reading and writing. It is at this juncture that the microcomputer moved beyond its role of providing a new, albeit dynamic, means to reach previously established goals, to providing a medium through which new and previously unattainable educational goals can be reached.

The teachers introduced a student newswire service known as the

"Computer Chronicles" in their classrooms. Students at a variety of distant sites exchange newspaper articles they have written as well as ones written by students in the network to produce local editions of the Computer Chronicles newspaper.

The Computer Chronicles helped the teachers establish learning environments which were organized for communicative purposes and not just as an exercise for teachers to evaluate. The presence of an audience for writing, in the form of classmates, parents and peers in Hawaii, Mexico and Alaska, was a crucial ingredient in giving students a purpose for writing. This writing for a purpose and not "just writing" or even writing on the computer, subordinated students' concern for the mechanics of writing to the goal of communicating clearly .

The presence of changes in teacher-student relationships and curriculum in conjunction with absences of changes in classroom organization leads us to consider two types of accounts about the impact of computers on education. One proposes that classroom culture will dictate the organization of classroom computer use; the second says that the availability of microcomputers will cause wholesale changes in education. We are inclined to dismiss both interpretations as overstated and are more inclined to adopt the view that characterizes the relationship between classroom organization and computer use as a mutually influential one.

Some Consequences of Peer Interaction at the Computer

The teachers wanted their students to master the operation of the microcomputer and be able to use the microcomputer for academic tasks e. g., composing poems and solving problems. The teachers started the students' learning process at the computer in a decidely social manner: pairs of students worked together to accomplish assignments. This arrangement enabled us to examine whether pairs of students working together gain benefits that do not accrue to students working alone.

When pairs of students were placed together at the microcomputer, they cooperated in the accomplishment of the task by dividing the labor between them. Verbal interaction was a particularly important medium in these situations, because the students working together talked out loud to each other. The act of verbalizing material led to cognitive restructuring on the part of the students who were attempting to explain. Verbal interaction was also important because it led students to hear different points of view, which, in turn, lead to cognitive conflicts. The resolution of these conflicts required the students to examine their own understandings and to consider different viewpoints.

The students divided the task in two principle ways: sequential processing and parallel processing. It was by dividing the labor that students completed the task assigned to them by the teacher.

Pairs of students divided the tasks sequentially when they used software which prompted students to pick from pre-determined choices. Students either alternated access to the keyboard every time the machine provided a prompt or conducted a series of operations before turning the keyboard over to the other student. Students soon settled on the "story" as the turn-alternation unit. At this point, one student entered a complete story while the other student provided assistance in the form of comments and suggestions about technical operations of the program and the computer.

Pairs of students divided the task _in parallel_ when they used software which enabled them to enter complete texts. While one student was engaged in entering text in response to general hints provided by the software, his or her partner was engaged in monitoring computer operations such as the use of the return or control keys and monitoring writing operations such as spelling, grammar, sentence structure and the overall coherence of the composition.

A general trend from sequential processing to parallel processing appears when the division of labor is examined across the whole school year, The most accelerated point of the transition occurred when the software changed from program controlled to user controlled. The shift from sequential processing to parallel processing seems to have been influenced by the design of the machine and the design features of the software that the students were assigned to use.

A Holistic Approach to Computer Literacy

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.

The teachers in this project 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 courses. 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 first through learning to program the computer. But, for others, that power could and should come, we feel, from first learning 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 interface, 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 element in teaching. Instead, teachers can capitalize on the seemingly ubiquitous presence of local experts. In each of our classrooms there were students who were highly motivated and knowledgeable about computers; we are recommending that this expertise be systematically exploited by encouraging students who are learning about computer operations to seek out these "computer tutors."

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 have benefits; the students in need of help gain help, and the previously unsuccessful student now 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 penetrate. 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 which take the discourse form of "if you have a problem, then do x" need to be available to students. The intent of diagnostic instructions is to encourage students first to 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.

Functional Learning Environments for Writing

The word processing systems that are available on microcomputers have been touted as possessing the solution to problems in writing (Lipsom and Fisher, 1983) because they facilitate the production of manuscripts. Printers are said to facilitate the writing process because students find the immediate production of neat, professional looking copy to be highly rewarding and motivating (Malone, 1981; Miller, 1984; Levin et al, 1982; Lipsom and Fisher, 1983).

We, too, are impressed with the utility of word processors and printers; however, we do not think that word processors *per se* are responsible for improved writing. In and of themselves, computers can not solve the problem of teaching students to read and write. While we have found that a microcomputer alone can not transform unskilled writers into skilled ones, it does help organize a medium that makes a new social organization for writing possible. The microcomputer works effectively in language arts when tasks that are organized for it are coordinated with tasks that are carried out in other parts of the curriculum (Mehan, Miller-Souviney and Riel, 1984). It is the creation of functional learning environments which utilize the computer as a tool to meet educational goals, and not the computer treated as a teaching machine that dispenses knowledge to students, which has positive effects on the writing process.

Functional learning environments, in which reading and writing were arranged for communicative purposes, gave students a goal for writing: to share their ideas and concerns with other students, some of whom were local, some of whom were distant. The public nature of writing provided motivation for re-writing and editing, giving students increased knowledge of word processing and control over the composing process.

Dynamic support provided by the interactive capabilities of the computer minimized the students' concern for the mechanics of writing and maximized attention to the flow of ideas and the process of writing, resulting in improved quality and fluency. By arranging learning environments in which computer based support was gradually removed, students gained control of writing by gradually assuming the parts of the task initially accomplished by the computer.

Students worked in teams to generate new articles or to edit those received from other locations. These cooperative working sessions facilitated the division of the newspaper writing task among the students. While one student concentrated on the mechanics of writing, another student concentrated on the generation of ideas. Cooperative working sessions also created a local audience for writing. The presence of another person during the writing process helped a student generate ideas and provided immediate responses to the written text.

While students in all classrooms improved their reading and writing skills beyond grade level expectations, the most impressive improvements appeared in the classroom taught by the skilled teacher who integrated the microcomputer into her language arts curriculum, had previous experience using computers and had prior experience teaching at grade level. Students in her classroom gained, on the average, 3 grade levels in language mechanics and 2 grade levels in language expression on standardized tests. Students did not improve as dramatically in classrooms where some of these features were absent (e. g., where there was a novice computer user, or the teacher was inexperienced teaching language arts as an integrated activity). Therefore, while it is difficult to say how much of students' improvement, if any, can be attributed to the computer alone, the results of our research suggest that a combination of features (computer knowledge, teacher experience, the integration of the computer into functional learning environments) had a positive effect on students' learning.

Computer Activities in a Bilingual Setting

We paid particular attention to the way in which the computer was introduced into the bilingual classroom because this setting had many of the features we would expect to find in many public schools: the teacher was recently assigned to teach at a new grade level, was participating in co-teaching pull-out programs for bilingual students, was learning a new method for teaching language arts and had a class composed of low achieving and LEP students.

The course of development of the integration of the computer into language arts activities was uneven. The first third of the year was spent establishing schedules and routines, modifying software and activities to accommodate younger and bilingual learners and providing students with lots of practice on machine operations. The modifications included providing many points of entry into the software systems and using social resources to assist the young learners, especially with the computer commands that were in English. Although mastering computer operations was particualrly difficult for the LEP students, the teacher did not reduce the level of instruction presented to them. Instead, she imported social resources, including older students from neighboring classrooms and members of the research team, to permit the students to engage in the tasks at the same level as the rest of the class. While this strategy proved to be laborious, it was effective. By December, the children, including the LEP students had overcome difficulties with procedural matters and were beginning to participate in computer activities profitably.

During the second third of the year the teacher learned to develop software in Spanish. The teacher's commitment to learn to program interactive texts in Spanish provided the LEP students with a significant, new entry point into computer activity. Instead of being a consumer of other's products, she became a producer of her own products. Programming, it seems, provided her with a sense of control over the technology, concrete ideas on what to do next, and allowed her to take better advantage of the specific resources found within and outside her classroom.

During this period the teacher also concentrated on a single computer based activity, "The Computer Chronicles." Not coincidentally, it was during this period the students´ increased their skill in manipulating the computer and associated software. The students were able to do some text editing on-line and they collaborated readily to complete tasks assigned to them by the teacher. These changes were as evident in LEP as English monolingual students, indicating that the teacher was successful in helping both groups of students perform similar tasks at similar levels.

For the last months of the project, the classroom computer activities required the students to compose text and to modify their drafts on the computer. As in earlier times during the year, the students´ progress through these activities was uneven; social resources were relied on heavily at the beginning of this period, and gradually receded in importance as students learned the editing and composing tasks.

The bilingual teacher´s experiences with the computer are indicative of the experiences we´d expect to find when a novice computer user attempts to introduce a micromputer into a classroom composed of low achieving and bilingual students. The process was laborious and at times exasperating. The teacher had to go to great lengths to balance her interest in this novel device with her commitment to mandated curriculum. The students, especially younger and LEP students, developed computer expertise at a slower rate than students in the upper grades. The teacher's commitment to organize her classroom environment such that younger and LEP students engaged in comparable educational activities (albeit with increased social support) represented an impressive antidote to the tendency of providing reduced levels of instruction to under achieving students.

Teaching Problem Solving Strategies

The transfer of knowledge from one domain to another has been hard to detect. When transfer does occur, it seems to be when certain linguistic mechanisms operate or when specific environmental conditions are in place. Naming the problem solving situations, providing direct instruction and practice, labeling the relevent strategies, explicitly stating the relationships between basic and transfer problems are some of the verbal mechanisms that can induce transfer (LCHC 1983). Transfer can also be induced by rearranging the socio-cultural environment. An overwhelming amount of our daily life is routine. We perform the same actions, in the same order, day after day. When we repeat the same "solution" to these problems day after day, the connection between problem and solution becomes deeply ingrained, thus minimizing or disolving the problem of transfer entirely.

One of the teachers arranged the learning environment in his classroom so that these conditions for transfer were present. He provided intensive, systematic and direct instruction on problem solving strategies via a curriculum dubbed "The Problem of the Week." He provided verbal labels and formulations of the problem solving apparatus for students' use. He arranged two problem solving situations that had many surface features in common, one within the regular classroom and the other in the computer lab he taught. When he took his sixth graders to the computer lab, he used LOGO as an environment in which students were to apply the problem solving strategies they had learned in the classroom.

In addition, he divided his classroom into two groups for instruction in the computer lab, one a compositional and the other a decompositional group. In the compositional approach, as found in Papert et al (1979) and Papert (1980), students were first introduced to elements and were instructed to compose final products from the elements. In the decompositional approach, the stuents were presented with complete entities and were asked to analyze them by manipulating and modifying them.

Students' performance was measured using problems from the school's standard math curriculum, the Brookline Test of problem solving and a locally devised test of LOGO Knowledge in a pre and post test format and by examining the process of students' problems solving as captured in students' notebooks.

The performance of the class as a whole was compared from the pre test to the post test. On five of six Heath math problems, the students showed statistically significant improvement during the school year.

Students showed improvement on three of the four Brookline Test questions designed to test students' ability to solve problems in the LOGO domain. The results of the LOGO Knowledge Test indicate that the students' knowledge of LOGO increased from the beginning to the end of instruction.

The performance of the Compositional and Decompositional groups was also compared on the Brookline and LOGO Knowledge Tests. As expected, the compositional group performed better than the decompositional group on the LOGO Knowledge Test which assessed specific LOGO maneuvers which were a part of that group's explicit curriculum. Also as expected, the decompositional group showed more improvement than the compositional group on the Brookline Test which assessed students' application of problem solving strategies.

Students taught by the decompositional approach seemed to approach the programming problems differently than the students taught the compositional way. The decompositional group planned their products in advance while the compositional group treated their notebooks as record-keeping devices after they completed their work.

Based on these test results, we feel comfortable concluding that students who receive intensive and systematic instruction in problem solving and have the problem solving apparatus formulated for them explicitly can learn problem solving strategies and apply them to new problems that have a similar logical structure with different surface features. We are more cautious about our results concerning the utility of the compositional and decompositional approaches to teaching a programming language (LOGO) because our test data are not statistically significant.

Educational Implications

We are concerned about the resources that a teacher must marshal in order to accomplish the twin goals of computer mastery and academic learning.

Some suggestions for arranging the everyday classroom context to meet these goals based on the several strands of research that we have reported follow, as well as some warnings.

Teachers Teach, Machines Mediate

Computers extend rather than replace teaching done by teachers. Used properly, computers can extend the power of students to create, analyze, compare, examine and understand. Computer facilitated environments can promote creative thinking, extend systematic inquiry and problem-solving, and establish important skills for cooperative work, all skills that are vital for participation in our present and future society. Students need to learn more than facts, including how information is collected, stored and utilized to solve problems or create new understandings.

Educational Technology and Educational Policy

Educational innovations need to be driven by educational policy rather than by the availability of technology. When computers first made their way into schools, often under the arms of enterprising teachers (Sheingold et al, 1983), the problem was finding the appropriate educational software. The teachers in this and other studies (Cazden, Michaels, Watson-Gegeo, 1985; Heap, 1985) have taken a significant step beyond isolated computer use by demonstrating that it is possible to integrate computers into major curricular areas.

If computers are going to have a significant impact on schools, and not just be confined to exceptional teachers, then schools and school districts have to adopt a comprehensive plan for computer use. Simply saturating a school with the newest machines is not likely to result in innovative uses of technology.

The history of innovation in education (Sarason, 1982) has shown that attempts to institute change have failed unless the implications of the innovation for all aspects of the school system are taken into account. While the details of such a proposal are too complex for this space, two principles seem important: (1) change must be school wide and involve administrators and parents, not just teachers; (2) a consistent plan and program that integrates students of differing ability, curricular areas and grade levels is required.

Functional Learning Environments

Educational technology makes it possible to create learning situations in which students can be engaged in activities that they find interesting and exciting for their own reasons and which accomplish the educational goals of their teachers. Teachers established functional learning environments by relating the computer activities to other educational tasks the children were doing. The goal was to link computer work with other classroom work to establish a mutually supporting context in which similar skills could be applied. The teachers perceived this coordination of otherwise unrelated activities as potentially the greatest source of support for the children's computer work; after all, the students spent approximately eight hours a week on language arts and only 30 minutes a week on the computer.

Educational technology can create new avenues for social exchange and cooperative learning. Fears that computers will result in students working in isolation removed from all forms of human interaction can be dispelled by watching students in classrooms organized to promote peer interaction. Students solve problems collabatively, often with their teachers as partners. More, not less, social interaction results when technology is used to foster joint problem solving.

While it may be true that exceptional teachers can accomplish the goals associated with an integrated language arts curriculum without a computer, well-designed computer software can empower good teachers by providing them with guidelines for integrating a range of new tools with their teaching skills.

Networks of Social Support

Networks of social support are vital to make educational technology effective. There is a range of different ways this support can be provided but without it, innovative uses of computers are not likely to succeed.

Given our pedagogical goals, we selected software that had two important characteristics: One, it was user controlled; it could be modified by the teacher, translated into Spanish, or entirely new activities could be created in either language. Two, it changed the type and form of participation as the student became more skilled; if the student was new to the task, such as writing an essay, the software provided plenty of prompts to support and encourage writing; as the student improved the prompts diminished and the student did most of the work independently. For our purposes, this flexibility was very important. The bilingual teacher, for example, used the Spanish versions (some that she developed as she became more competent with the computer) and the interactional capabilities of the software to accomplish three essential goals: (1) to engage the whole class in the same computer activities, regardless of language proficiency, (2) to help LEP students apply their Spanish language and literacy skills readily to computer work, thus taking full advantage of the students' intellectual resources, (3) to help the students use their Spanish to work in English. Software was selected, modified or developed in the context of these goals.

People are a vital part of the network of social support for students who are learning academic tasks via microcomputer. Support provided by students or the participant observers was vital for all students, but especially for the LEP students who needed help with English, to decipher or perform assigned computer tasks. This additional support was enough to help the students do computer activities they otherwise could not do. As the students progressed in their computer work, the amount of help was reduced and the nature of the help changed. The social support was aimed at how to do a task, and more how to improve work done previously; or it provided guidance to LEP students about how to do in English what had previously been done only in Spanish.

Social support is as important to the teacher's development as it is to the student's development. Research is showing that adults as well as students seek out social experts rather than print material to help them acquire new technical skills (Bannon, 1985). Finding ways to provide this support is vital. Simply providing teachers with new computer equipment is clearly not sufficient. The extra-curricular help provided by the research team facilitated the teachers' rapid acquisition of the technical aspects of computer operations. In addition, it provided the teachers with valuable resources not available in the immediate environment (e. g., the use of participant observers to assist the children) and access to local experts who represented an indispensible crutch while teachers explored uncertain terrain.

This experience suggests that teacher training must be continual but be reduced as teachers gain mastery. Teachers need to acquire "threshold knowledge" about computers, including knowing how to select or modify the software the children will use and elementary trouble shooting, and this knowledge can be acquired while helping the students with their assignments. It is not necessary to postpone all worthwhile computer activities until the teacher is well-prepared. Just as multiple entry points were provided for the students, they must be provided for the computer-novice teachers. There is no one single way of becoming competent with computers.

Computer Literacy

As it is frequently taught, computer literacy is not a fruitful approach to computer use. It is not necessary to separate the teaching of machine operations from the teaching of machine uses; doing so is yet another example of a decontextualized approach to education, and has the potential to continue the existing educational stratification of students along social class lines. Students can learn about machine operations by using them to accomplish academic tasks. Integrating computers into the curriculum and using them as tools gives students a much richer sense of their power than spending time learning all the names and functions of the computer components separate from and before learning about computer uses.

Educational Tracking

Educational tracking can be reified by computer technology, i.e. when low income and low achieving students are given computerized drill and practice games while high achieving and high income students are exposed to simulations and tool use activities. This differential educational treatment is justified on the grounds that low achieving students need simplified tasks and massive doses of reinforcement, while high achieving students need advanced and challenging work. This rationale is uninformed and its concomitant stratification is unnecessary. When functional learning activities are created with dynamic support for low achieving students their scores on educational skills show improvement that is similar to that of students who are classified as gifted.

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APPENDIX 1

SELECTING PROMPTS AND RUBRICS

From Grubb (1981)

On the following pages are specific prompts you can use to have your students write stories (narrative writing), descriptions (descriptive writing), explanations (expository writing), and letters (practical writing). The prompts have been written for use with the different grade levels of SPECTRUM OF ENGLISH. You will also find prompts for persuasive writing for Grades 7 and 8, where this kind of writing is first introduced. With some word adjustment, you will probably be able to use prompts designed for one grade level with any group of students. If, for example, you are teaching from SPECTRUM OF ENGLISH Green (Grade 5), you will probably also be able to use slightly reworded prompts from Purple (Grade 4) and Gold (Grade 6) to evaluate your students' writing ability.

After each set of prompts, you will find a four-point and a six-point rubric, designed for use with the specific kind of writing elicited by the prompts. You can use these rubrics to score your students' compositions.

Prompts for Narrative Writing

Spectrum of English Yellow (Grade 3)

Imagine that you have found a magic wand. Think about how you found the magic wand. Think about how you will try to use the magic wand. Think about what will happen when you use the magic wand. Then write a story that tells about you and the magic wand.

Spectrum of English Purple (Grade 4)

Imagine you are taking a trip on a rocket. Think about what you will do when the rocket takes off. Think about what you will do during the trip. Think about what you will do when the rocket lands. Then write a story about your rocket trip.

Spectrum of English Green (Grade 5)

Imagine you and a friend are exploring another planet. Think about the most exciting adventure you and your friend would have there. Think about what would happen at the beginning, in the middle, and at the end of your adventure. Then write a story about the adventure you and your friend have.

Spectrum of English Gold (Grade 6)

Remember a time when you felt very frightened. Think about what happened to make you feel frightened. Think about what you did when you felt frightened. Think about how you finally stopped feeling frightened. Then write a story about the time when you felt frightened.

Spectrum of English Amber (Grade 7)

Imagine that while you are exploring a strange jungle, you become lost. Think about how you became lost. Think about what you do when you discover you are lost. Think about how you find your way back out of the jungle. Then write a story about being lost in the jungle.

Spectrum of English Emerald (Grade 8)

Imagine that you are trapped in an underground mine. Think about what you do when you discover that you are trapped. Think about the different methods you use to try to get out of the mine. Think about how you finally get out. Then write a story about being trapped in an underground mine.

Rubrics for Narrative Writing

Because it is used far less often than the four- or six-point rubrics, the nine-point rubric has not been included. If you need a nine-point rubric to assess the writing of a group of advanced students, expand the six-point rubric given here, using the nine-point rubric on pages 15–18 as a guide.

Four-Point Rubric

4 This is an excellent composition, with all or most of the following characteristics:

- ☐ a clear sequence of events which is an appropriate response to the prompt and which is introduced at the beginning of the composition
- ☐ clear development of the story, without irrelevant descriptions or explanations
- ☐ good organization, including a clear beginning, middle, and end
- ☐ fresh, vigorous word choice
- ☐ a variety of interesting details
- ☐ correct and appropriate structure in all or almost all sentences
- ☐ very few or no errors in the use of punctuation marks, capital letters, and spelling

3 This is a good composition, with all or most of the following characteristics:

- ☐ a sequence of events which is a good response to the prompt but which may not be entirely clear in every part of the composition
- ☐ good development of the story, which may, however, be marred by an irrelevant description or explanation
- ☐ good organization, which may, however, include undue emphasis on the beginning or the end of the story
- ☐ good word choice, which is, however, not particularly fresh or vivid
- ☐ sufficient details to maintain reader interest
- ☐ correct and appropriate structure in many or most sentences
- ☐ some errors in the use of punctuation marks, capital letters, and spelling

2 This is an adequate composition, with all or most of the following characteristics:

- ☐ a story line which is an adequate response to the prompt but which may be unclear in many parts of the composition
- ☐ adequate development of the story, which, however, probably includes one or more irrelevant descriptions or explanations
- ☐ organization which is not completely clear
- ☐ adequate word choice
- ☐ very few details which relate to the story
- ☐ incorrect or inappropriate structure in many sentences
- ☐ serious errors in the use of punctuation marks, capital letters, and spelling

1 This is an inadequate composition in which it is difficult to understand what the writer is trying to say. It may be very short or very long and rambling. The composition has all or most of the following characteristics:

- ☐ some indication of an attempt to respond to the prompt, although the story line is unclear
- ☐ story development which is unclear or completely lacking
- ☐ no understandable organization
- ☐ unspecific, immature word choice
- ☐ complete lack of details which relate to the story
- ☐ incorrect or inappropriate sentence structure throughout
- ☐ many serious errors in the use of punctuation marks, capital letters, and spelling

Six-Point Rubric

6 This is an excellent composition, with all or most of the following characteristics:

- ☐ a clear sequence of events, which is an appropriate

Rubrics for Descriptive Writing

Because it is used far less often than the four- or six-point rubrics, the nine-point rubric has not been included. If you need a nine-point rubric to assess the writing of a group of advanced students, expand the six-point rubric given here, using the nine-point rubric on pages 15–18 as a guide.

Four-Point Rubric

4 This is an excellent composition, with all or most of the following characteristics:

- ☐ a clear topic, which is an appropriate response to the prompt and which is introduced at the beginning of the description
- ☐ a clear development of the description, with few or no irrelevant stories or explanations
- ☐ good organization, including an introduction and a conclusion
- ☐ specific, vivid word choice
- ☐ sensory detail
- ☐ correct and appropriate sentence structure in most or all sentences
- ☐ few or no errors in the use of punctuation marks, capital letters, and spelling

3 This is a good composition, with all or most of the following characteristics:

- ☐ a topic which is a good response to the prompt but which may not be completely clear throughout the composition
- ☐ adequate development of the description, which may, however, be marred by an irrelevant story or explanation
- ☐ good organization, which may, however, lack a clear introduction or conclusion
- ☐ appropriate word choice, which is, however, not particularly vivid
- ☐ sufficient details to make the description clear

- ☐ correct and appropriate structure in most sentences
- ☐ some errors in the use of punctuation marks, capital letters, and spelling

2 This is an adequate composition, with all or most of the following characteristics:

- ☐ a topic which is an adequate response to the prompt but which may be unclear in many parts of the description
- ☐ minimal development of the description, which may include several irrelevant stories or explanations
- ☐ unclear organization
- ☐ unspecific or immature word choice
- ☐ few details which contribute to the description
- ☐ incorrect or inappropriate structure in many sentences
- ☐ many errors in the use of punctuation marks, capital letters, and spelling

1 This is an inadequate composition, in which it is difficult to understand what the writer is trying to say. The composition has all or most of the following characteristics:

- ☐ some indication of an attempt to respond to the prompt, although the topic of the description may be unclear
- ☐ development which is unclear or completely lacking
- ☐ no understandable organization
- ☐ unspecific, immature word choice
- ☐ complete lack of details which contribute to the description
- ☐ incorrect or inappropriate sentence structure throughout
- ☐ many serious errors in the use of punctuation marks, capital letters, and spelling

Six-Point Rubric

6 This is an excellent composition, with all or most of the following characteristics:

Appendix 2

Functional Computer Literacy Test

Introduction

Try to make the person feel as comfortable as possible. This is not a test, it is a discussion about the computer and what the person knows. They may learn some things that they did not know. Say something like:

> We want to know what you have learned about the computer this year. I am going to ask you some questions about the computer and how you use the computer. You will know the answers to some of these questions, but not all of them. You may learn some things about the computer. Everything you say is important to us because it will help us decide what to teach children about computers next year.

Hardware Questions

General instructions: point to the part of the computer indicated and ask the person to identify the part and tell what it is for. If the persons response is similar to one listed, mark that response. If it is different, either list it or if too long, index tape recording by T. For no response, mark O.

1. What is this? (Keyboard)
   What does it do? (lets you talk to the computer) (types letters)

2. What is this? (Monitor) (Screen) (TV)
   What does it do? (shows what is happening in the computer) (shows you what you are doing)

3. What is this? (Printer)
   What does it do? (type information on disk)

4. What is this? (Disk Drive)
   What does it do? (reads and writes information on the disk)

5. What is this? (Central Processing Unit)
   What does it do? (make the computer work)

6. What is this? (Memory Chip)
   What does it do? (store information)

7. What is this? (WA:SYSTEM Disk)
   What does it do? (starts the Writers Assistant) (reads information) (transfers information)

8. What are some of the things you have to do to be careful of discs?
   Probe: What are all the things you shouldn't do with discs?
   (food) (magnets) (grey area) (heat, cold) (bend)

9. What would you do if you put your disk in and turned on the computer and the screen was blank?

   If that didn't work is there anything else you can do?
   Repeat this question until the student says "no", number the responses
   (turn on the computer) (turn the contrast) (check if plugged to power) (check if plugged to computer) (ask a friend) (ask the teacher) (read the charts)

Working Knowledge

General Instructions: Turn off the computer and monitor. Show the person a WA:SYS and WA:TEXT disk. Ask the person to use the Writer's Assistant to type a sentence. Hand them a card with the sentence "Help, I am stuck in this computer." Tell them to save it in a file with their first name and to print one copy.

Indicate the sequence by numbering each step as the student does it.
Put a check mark if the student self corrects after an error.
Put a + if you needed to give some prompting.
Put a * if you had to tell the person how to do it.

Insert WA:SYS disk
Turn on computer
Turn on monitor
Selects (1) Writer's Assistant from menu
Inserts WA:Text disk
Enters By-line in response to "Hi, who are you" (optional)
Names file (in response to "what text do you want to work on?")
Uses (I)nsert command to enter text
N.B.: list here any cursor movement or use of control keys

Enters text
Closes with control-C
Leaves file with (Q)uit and (U)pdate
Removes WA:Text disk
Turns off machine (optional)

Writer's Assistant Commands

General Instructions: You will ask the student to demonstrate knowledge of a number of procedures in a step by step fashion. If a student cannot do part of the task, show the student how to do it. Then move to the next item. IT SHOULD NOT SOUND LIKE A LIST OF QUESTIONS. Say something like:

> OK, now we are going to look at another file on this disk and I will ask you some questions. If you don't know how to do something, I will show you how.

Find a file:

1. Give the person WA:SYS and WA:TEXT and ask them to see if they can find a news story written by John Drew on March 10. (NEWS-JD310). If not ask the person to find the file NEWS-JD310.

2. What would you do if the file was not on the disk? (look for another disk) (ask teacher)

3. Read the story. "What does it say?" "Do you want me to read it?"

Cursor Movement:

1. After student is in the file: What is that blinking light? (cursor) What does it do? (tells place)

2. Put the cursor on the word "baseball."
   (spacebar) (Control-I up/down key) (<-/-> key)

3. Do you know any other ways to move the cursor?

4. Can you make the cursor move word by word? (Control-I)

In, Drop, Xchange:

1. Insert the word "news" before the word "story" on line 3.
   Cursor movement: (spacebar) (CTRL-I) (up/down key) (<-/-> key)
   Command: (I)n (news) (CTRL-C)

2. Delete the word "night" on line 2.
   Cursor movement: (spacebar) (CTRL-I) (up/down key) (<-/-> key)
   Command: (D)rop (spacebar) (CTRL-I) (CTRL-C)

3. Exchange the word "father" for the word "mother"
   Cursor movement: (spacebar) (Control-I) (up/down key) (<-/-> key)
   Command: (D)rop (spacebar) (CTRL-I) (CTRL-C)
   (I)n (mother) (CTRL-C)
   (X)change (mother) (CTRL-C)

Aline and Word commands:

1. Do you know how to check the spelling of the word "two?"
   Cursor movement: (spacebar) (CTRL-I) (up/down key) (<-/-> key)
   Command: (W)ord

2. Can you center the title of this story?
   Cursor movement: (spacebar) (Control-I) (up/down key) (<-/-> key)
   Command: (A)line

Set the Environment:

1. Do you know if you can change the margins of your writing?

2. If yes, do you know how to do it?

Help command:

1. If you don't know how to use a certain command, what do you do?
   (read instructions) (ask another student) (use Help command)
   (ask teacher)

2. Do you know how to use the Help command?

Other commands:

1. Are there any other commands that you know that you can show me?

Quit commands:

1. Show me how you finish your work/leave the file. (CTRL-C) (Q)uit / (S)save
   (Q)uit / (U)pdate