

COMPUTERS IN CLASSROOMS:
A QUASI-EXPERIMENT IN GUIDED CHANGE
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FINAL REPORT

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CHAPTER 1:
INTRODUCTION
Hugh Mehan

Prevailing Uses of Microcomputers in Schools

Recent national surveys of computer use (CSOS, 1982; Tucker, 1983) and surveys conducted in the San Diego area (Miller, 1983, Boruta et al., 1983; Cohen, 1984) have shown that microcomputers are used primarily to teach programming and to provide drill and practice in basic skills. The current state of computer use in schools presents educators and the society at large with a number of problems. First, the use of microcomputers for drill and practice does not fully utilize the capabilities of this technology for education. Second, women, lower income and ethnic minority students do not have the same access to educational technology as do their male, middle income, and majority counterparts. Third, treating computer programming as the end point of a computer curriculum overlooks the needs of society and the work place.

Basic Skills Instruction

The most prevalent instructional application of computer use today is for basic skills instruction. Basic skills instruction usually means computer Aided Instruction" (CAI) (see Atkinson, 1972; Suppes, 1980). The extent to which CAI software is used is indicated by a recent study of 2000 computer using teachers who were asked: "What are your favorite educational software

programs?" (Patterson, 1983). Of the 93 programs identified, 27 were for professional and administrative purposes, and 66 were for instructional purposes. Nearly all of the instructional programs were devoted to drill and practice or reinforcement of existing skills in math, social science and English. They were not used to generate new instructional activities.

When computers are used for basic skills instruction, students are commonly given drill and practice which reinforces instruction on material already presented in their classrooms. The material to be learned and the sequence in which it is learned is rigidly fixed by the teacher and the software. The material to be presented to students is restricted to a specific problem domain, offers a narrow range of response options and is presented to the students in very small steps (Amarel, 1983; Riel, 1983). When a correct answer is selected, the students are rewarded with a visual or musical display, often unrelated to lesson materials.

Programming

The second most common instructional application of computer use today is for "computer literacy." Computer literacy has come to mean teaching students to program computers, primarily in the BASIC language.

Computer programming is emphasized in computer literacy curricula because programming enables students to gain control of the machine (Papert, 1980). Another reason given for emphasizing programming is that it strengthens students' higher level reasoning skills. While there is no reason to argue against the first premise, there is little evidence to support the

second (Pea and Kurland, 1984; see Chapter 8 of this report). Even if there were considerable evidence to suggest that learning to program enhances higher order thinking, it may be short sighted to teach all students to program in BASIC.

BASIC is a general purpose programming language. While its linear structure makes it relatively easy to learn initial commands and statements, this same structure makes it difficult for beginning students to create any but the most rudimentary programs. BASIC is also limited in that it does not easily allow for hierarchically arranged programming procedures in the more modern languages, PASCAL and LOGO. Whether working in BASIC, PASCAL or LOGO, however, students receive only a limited sense of the computer's power. With special purpose languages such as Interactive Texts or spread sheets, students develop a richer sense of how to structure problems effectively and to approach problems in a disciplined way, (i.e., two of the general or "metacognitive" skills that some cognitive scientists believe can be widely applied to solving problems).

Problems With Current Uses of Microcomputers

We see a number of problems with the current uses of microcomputers in schools. The present pattern does not capitalize on the full capabilities of the technology. Furthermore, prevailing educational uses stratify access to microcomputers along social class, gender, and ethnic lines. Of equal importance, they do not match the ways in which computers are used in the work place.

Underutilization of the Computer's Capabilities

The fast pace and packaged format of CAI drill and practice software provides little opportunity to deliberate, to reconsider, or to challenge the prespecified answers. These programs assume limited knowledge on the part of the students and aim to strengthen and broaden that knowledge by repeated exposure to a similar class of exercises (Amarael, 1983). Little attempt is made to extend or apply existing knowledge.

While there is some evidence to suggest that microcomputers can deliver basic skills instruction better than conventional techniques (Kulik et al., 1983), critics of such studies (Tucker, 1983) point to the methodological problems and omissions of cost comparisons. Typically, the effectiveness studies compare the effects of recently introduced CAI programs to conventional workbook activities. These comparisons may provide a statistically significant advantage for CAI. So far, effectiveness studies have not compared CAI to methods such as cross-age tutoring, which have also been shown to improve students' learning. The utility of CAI for improving students' basic skills diminishes when the high cost of computers is taken into consideration (Tucker, 1983).

Furthermore, when the novelty of working with computers wears off, CAI workbook pages do not have the motivating effect required to sustain students' interest (Malone, 1981). In addition, the current readability and graphic quality of electronic worksheets is poorer than printed workbooks, which makes their use as an alternative medium of communication between

teacher and student questionable.

Equitable Access to Educational Technology

While the most prevalent educational uses of microcomputers are basic skills instruction and computer programming, access to computers and their uses is differentially distributed. Ethnic minority and low income students receive a different kind of instruction on computers than their middle income and ethnic majority contemporaries. While middle class students, especially those who are in advanced programs (e.g., Gifted and Talented Education) receive instruction which encourages learner initiative (programming and problem solving), low income and ethnic minority students receive CAI instruction which maintains the control of learning within the program (CSOS, 1983; Boruta et al., 1983).

Males and females also have differential access to computers, (CSOS, 1983; Boruta et al., 1983), especially in secondary schools (Sheingold et al., 1983). In elementary schools that have established central computer labs, boys and girls have equal access. However, this equality is not duplicated during voluntary times on computers (recess, lunch, after school clubs). More boys than girls use computers in their spare time. The equality of access reported in elementary schools disappears in secondary schools. When students are divided into curricular tracks, (college preparatory, vocational and general education), a stratification of males and females becomes apparent. Males gain greater access to computer and math labs than females.

This tracking of students by gender and socioeconomic background through

different curricular tracks stratifies students' access to information technology. Differential access represents one of the ways in which the microcomputer can become a tool which contributes further to the stratification that already exists in our society. If only a few people learn to control computers, and most can only react passively to them, then we will have a system of stratification based on access to information technology (Schiller, 1981) that will make the ones based on economic capital (Marx, 1964) and cultural capital (Bourdieu and Passeron, 1977; Collins, 1980) pale by comparison.

The Needs of Society and the Work Place

The computer is a general purpose machine. It processes information that can be used for a wide variety of instructional and administrative purposes. These wide-ranging capabilities of the computer, coupled with parental pressure and pressure from business and industry, are the main reasons computers are having such a dominant impact on education. However, knowing that the computer can be used for almost any purpose does not tell schools what it should be used for. In fact, it is its flexibility that is so dazzling. Since the machine can be programmed to do many things, we must search for the constraints which tell us which computer applications make sense and which do not. We must also take into consideration the cost of applications in dollars, time and human costs.

As schools and universities organize educational curricula which involves computers, we need to insure that the instruction we provide our students will help them in the world of work. It is helpful, therefore, to

examine the ways in which computers are used at work now, and try to determine how computers will be used at work in the future.

While it is not entirely clear what school children need to learn now in order to be competent and useful in the 21st century, most computer scientists believe that in a few years very few people will be actually writing computer programs with general purpose languages. Increasingly, microcomputers are being used in business and industry for word processing, spread-sheet analysis, and data systems management--applications which do not require knowledge of general purpose computer languages. These business applications are being implemented, not by highly skilled programmers, but by employees learning to create electronic forms and spread sheets provided by special purpose user friendly programs (e.g., Visicalc, Word Star). Eventually, computers will write programs in response to spoken or typed requests made in ordinary English (Kay, 1983), further reducing the need to produce a multitude of general language programmers.

The shift in computer uses from those dependent upon general purpose programming languages to those using special purpose programs suggests that even though our society may rely heavily on the computer, we will not need vast numbers of programmers. Even though there is a shortage of general purpose programmers now, we are likely to need far fewer in the future.

The available evidence suggests that most jobs will not be found in high technology industries, nor will high technology require a vast upgrading of the American labor force (Levin and Rumberger, 1984). On the contrary, the proliferation of high technology industries is far more likely to reduce the

skill requirements in the U.S. economy than to upgrade them.

Levin and Rumberger (1984) cite Labor Department projections that say jobs for computer programmers will grow between 74% and 148% during the 1980s, while overall job growth will be only 22%. These percentages are misleading, however. The total number of new jobs for computer programmers is expected to be 150,000. Some 1.3 million new jobs are projected for janitors, nurses aides and orderlies. That is nine unskilled jobs in these categories for every computer programmer. New jobs for data processing machine mechanics will increase 148%, the fastest growing job category. But that large gain translates into an increase of fewer than 100,000 new jobs, while 800,000 new jobs are projected for fast-food workers and kitchen helpers alone.

There will neither be a proliferation of systems analyst jobs, nor will the high-tech jobs create demands for increasingly sophisticated work skills. On the contrary, the new technologies further simplify routine tasks and reduce the opportunities for worker individuality and judgment. In such diverse areas as office administration, data processing, drafting, and wholesale and retail trade, microcomputers are making it possible to employ persons with lower skills to perform what had previously been highly sophisticated jobs.

The results of this brief examination of the use of computers in the world of work have implications for the widespread teaching of programming presently pervading our curricula. Strictly on intellectual and academic grounds, it may be important for students to gain some exposure to

programming. Indeed, programming may enable students to gain a sense of how the computer operates and develop some skills in structuring problems. But, devoting years of a student's time to programming instruction can not be justified on the grounds that we are providing skills that students will require professionally (Tucker, 1983). We may need tens of thousands of general purpose programmers, but not the millions we will be producing with the current emphasis on programming in schools (Levin and Rumberger, 1984).

Instead of making programming the single entry point and the pinnacle of computer education curricula, it is important to provide students with "multiple entry points to expertise" (Levin and Souviney, 1983). Multiple entry points will enable students to use computers as powerful tools for a wide range of applications. For some students, that power will first develop through the ability to program the computer. But for others, that power could come from first knowing how to use the computer to write and edit text, to create music, graphics, and animation, and to organize information and communicate it to others.

Our Approach to Finding Solutions

Our overall goal as we work with computers in education is to address the three main problems in current computer use: (1) the underutilization of the computer's capabilities, (2) stratified access, and (3) the single avenue to the world of computing through programming. In the remainder of this chapter, we describe the approach we are taking to meet our goal. We describe some of the ways in which learning environments can be assembled that take advantage of the interactive capabilities of computers. The curricular

activities used in the classrooms in this project were produced by a unique collaboration between school teachers and university researchers. A discussion of this collaborative effort follows our description of the design features of functional learning environments.

Exploiting the Interactive Capabilities of the Microcomputer:
Creating Functional Learning Environments

One way to use computers to achieve equitable access and unique educational goals is to exploit the interactive capabilities of microcomputers for language arts and mathematics instruction. The availability of word processors, writing tools, computer labs and computer networks makes it possible to create learning environments which go beyond drill and practice and programming.

As we will point out in Chapter 4, microcomputers can be arranged to provide a communal resource to students, the use of which is not predetermined, but can be changed by students and teachers during the course of interaction itself. Interactive software enables teachers and students to modify the learning activity as instruction progresses. The open-ended character of learning environments such as LOGO (Papert, 1980), the PLATO mathematics lessons (Davis et al., 1977), and construction sets such as "Rocky's Boots" (The Learning Company), encourage users to build their own materials and see what happens by selecting components and connecting them. As students explore these activities, they move in directions not originally planned by teachers, thereby learning that problems have many solutions, not a single solution which is provided by the teacher.

Rather than looking at microcomputers as dispensers of certain knowledge or rewards, we explore ways to organize functional learning environments. The functional learning environments we have constructed in language arts and mathematics (see chapters 6, 7 and 8) (1) adopt a holistic approach to educational practice and (2) provide dynamic support to novices learning a task.

The Whole Task. A fundamental component of our approach to computer use is the belief that children learn most effectively by participating in whole activities with others. Through this participation in the whole task, others perform some aspects of the task which are too difficult for the children to accomplish on their own; in time, the children learn how to master the entire task alone (Luria, 1976; Vygotsky, 1978; Wertsch, 1979; Flavell, 1981; Griffin and Cole, 1984; and compare Piaget, 1970).

The holistic emphasis in our work contrasts sharply with atomistic educational practice. Children most typically work alone on subparts of a task in schools. When students accomplish all the subparts, they are expected to assemble these components into a unified whole on their own. In many standard reading programs, for example, children begin work on recognizing letters, establishing sound-letter correspondence and blending letters together to "read" words and sentences. These activities often occur in isolation from reading presented as a method for learning new things from text. Or, when students are asked to write compositions, they are first asked to write sentences, then paragraphs, and finally complete essays.

A clear example of the holistic approach to educational practice, and one many of us are familiar with, is the way parents teach their young children how to read (Ninio and Bruner, 1978). From the beginning, the social setting is parent and child, and the activity is reading a book. Initially, the child knows very little about the activity of reading and the mother must carry much of the work. As the child becomes familiar with the patterns, he or she may begin to participate in simple subskills such as turning the pages, or pointing to objects. As the child gains knowledge, what is expected of him or her shifts. Now the child is asked to provide names for objects or to tell what is happening in the story. Slowly the attention is shifted from pictures to words and the child begins to recite well learned pieces of the story. This skill becomes more and more flexible as the support provided in the book and by the mother recedes, and the child becomes an independent reader.

The activity has remained constant through the whole process: parent and child sitting together reading the book. What has changed is the degree of participation in the activity on the part of the child. This dynamic network of support has been referred to as "The Zone of Proximal Development" (Vygotsky, 1978; Brown and French, 1979; Griffin and Cole, 1984). The activity that is accomplished by the mother and child ("the zone"), provides a good prediction of what the child will soon be able to accomplish on his or her own at some future time. Learning to do the pieces in the context of the whole guards against becoming so obsessed with accomplishing subgoals that the student never understands the relationship of the subparts of those actions to the whole task.

In short, we have drawn a parallel between a holistic approach to teaching reading (LCHC, 1982) and a holistic approach to learning to use a microcomputer. In doing so, we have found that microcomputers can be used to provide children support for elements of writing tasks they have not yet mastered. Furthermore, this support can gradually be removed as the children become more skillful, as we describe in the following discussion of "dynamic support."

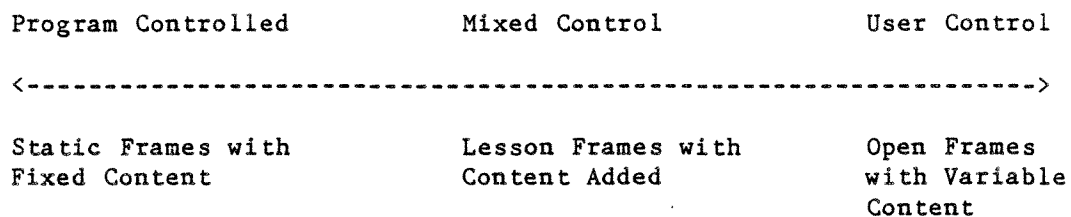
Dynamic Support. "Dynamic support" refers to the process of systematically decreasing amounts of assistance provided to novices as they progress in expertise and gradually assume parts of the task initially accomplished by an expert. In a properly arranged teacher-student-computer environment, there is potential for creating the kind of dynamic support necessary to dramatically improve students' learning.

Riel (1982) showed that the microcomputer can provide dynamic support to students with language disabilities. She found that children with language handicaps had greater difficulty than students with normal language development in making efficient problem-solving decisions when playing computer games. In a training study, Riel modified the computer software so that at first, most of the game parameters were controlled by the computer. As the players' skill increased, this support was gradually withdrawn. After several weeks, the game performance of the students with language handicaps was similar to that of normal students. In this way the computer was used to construct a "Zone of Proximal Development" which provided training in a variety of systematic, self-regulatory problem-solving skills as children learned basic materials.

Software is now available which, like the parent in the Ninio-Bruner reading example, systematically increases the degree and form of learner participation as skills develop. For example, in text editing systems such as QUILL (Bruce and Rubin, 1983), and The Interactive Writing Tools (Levin, 1982), texts are constructed which share the initiative between writers and readers along a continuum of support (Riel, Levin and Miller-Souviney, 1984). This continuum of support is shown in Figure 1.

Figure 1

A Continuum of Educational Software (from Riel et al., 1984)



At the program-control end of the continuum, "readers" of structured interactive text are invited to make simple choices about the direction in a story's plot. At the user-control end of the continuum, an interactive text or planner enables more skilled writers to take complete responsibility for writing. At the user-controlled end of the continuum, the computer offers high-level suggestions and provides prompts, leaving the lower-level writing activities in the hands of the student. Such writing tools make it easy for students to enter text by providing activities which range in the degree of support. Perhaps more importantly, they make it so easy to make changes in text that elementary school students can edit their writing as a functional everyday activity. Throughout these activities, the goal is for the quality

of writing to remain constant while the participation of the learner increases, as the amount of support provided by the computer decreases.

Dynamic support provided by the interactive capabilities of the computer subordinates the students' concern for the mechanics of tasks to higher order goals. By arranging learning environments in which computer based support is gradually removed, students gain control of learning by systematically assuming the components of the task initially accomplished by experts, in this case, represented by a teacher-computer configuration.

Teacher-Researcher Collaboration

While some of the sources of inequities in our society may best be attacked by change in organizational structures or by change in technology itself, we chose to affect change by a teacher-researcher collaboration because teachers are in closest contact with students and computers. The collaboration involved the systematic introduction of computer curriculum in a small number of classrooms accompanied with supporting knowledge and training. The computer curriculum was an extension of previous work conducted at UCSD to teach basic skills to small groups of specially selected students in resource rooms and after school clubs (LCHC, 1982; Riel, 1983; Levin et al., 1984). In this research project, we extended our educational efforts in two ways: first, to the education of a more diverse population of elementary school students; second, to operate within the the constraints of regular classroom configurations and educational curricula.

The classrooms had diverse student populations in terms of age,

measured ability, socioeconomic background and ethnicity (more details about the classrooms are provided in Chapter 2). The grade levels ranged from 2nd to 6th grade. The students' abilities were measured from the lowest CTBS quartile to GATE qualification. 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.

The teachers were involved in every stage of the project. The work was done collaboratively because expertise is distributed across the members of social groups. Our group dealt collectively with the issues that were crucial in determining how the computers would be used in the classroom. Some of the ways in which teachers guided the research are discussed in the following sections.

Evaluating Student Progress. Teachers took an active role in deciding what measures to use to determine student progress. They described the school administered standardized testing (CTBS) and Ginn reading level scores that would be available. The teachers and researchers worked together to design a set of pre- and post tests to measure the students' reading and writing skills.

Selection of Software. At the outset of the project, teachers were asked to formulate their teaching objectives, especially in the curriculum area in which they would be using computers. After teachers described their objectives, computer software was discussed in light of teacher goals. Both teachers and researchers were concerned about how to use the computer to

facilitate forms of interaction and learning that are different from the interaction that conventional forms allow. It was decided that all the software used on the project would be either "tool software" (i.e., software in which the goal is provided by the user and the software is used as a means to accomplish the goal) or software that encouraged discovery of conceptual skills.

Software that meets these criteria were discussed. Previous models of integrating software in teaching environments were presented by the teachers who had some experience with computers and reports were made by researchers about how software had been used in other research projects. Teachers decided which software they would use in their classrooms. The instructional activities that are described in Chapters 6, 7, and 8 were created by teachers as they experimented with integrating software with their teaching objectives.

Participation in Computer Chronicles News Network. Three teachers decided to make newspaper reporting and editing a central focus of their language arts curriculum. These teachers enrolled their students in the "Computer Chronicles News Network." The teachers who were not familiar with the software were encouraged to spend time writing and editing stories in the same manner as their students.

The teachers worked together and with members of the research team to formulate their plans for using the Computer Chronicles in their classrooms. For example, teachers discussed students' choice of writing assignments. One teacher felt that free choice would increase motivation. Past experience

indicated that the newspaper sections devoted to jokes and sports would be very popular selections if students were given free choice. The teachers were concerned with ways to encourage diversification. One teacher decided to provide more structure to the newspaper activity by assigning topics to the student reporters, pointing out that "cub reporters" never get to choose what they write about. Each of the teachers formulated a method of making newspaper assignments. Reports of successes and failures at project meetings helped the teachers find the most productive solutions.

The teachers organized means for evaluating, selecting, editing and doing the layout of their newspapers once stories were written and received from other schools on the network. The production of newspapers was discussed by teachers and researchers. Ideas of ways to adapt the "editorial boards" previously used in a resource room version of the Computer Chronicles to the classroom were generated. Two of the teachers decided to have a number of different boards, one for each newspaper edition, and keep the size small. Another teacher decided to have all the students participate in the production of each newspaper by dividing the class into small board meetings for each of the different sections of the newspaper. A third solution made the selection of stories into a reading center task.

The use of editorial boards led to discussions about the organization of editing in classrooms. The problem of coordinating stories once cut up and placed in folders according to sections and stories stored on disks was discussed. Solutions ranged from those that placed a major responsibility on the teacher to those that required more training of the students.

Data Collection and Observations. The teachers worked closely with the observers to determine which classroom activities to observe and tape. We adopted data collection and observation techniques that we have found to be productive in our previous projects (Mehan, 1979; Riel, 1982; Moll and Diaz, 1984). We agreed that observations would be made three times a week during the time that the central focus of the classroom occurred. We reduced the number of observations to two a week in January. The events to be videotaped were selected based on their coordination with other classroom activities and the production of a student's "product," i.e., a document. All observation notes taken in classrooms were made available for teachers to read. All videotapes were available for viewing, and teachers retained the right to end any taping sessions and erase any videotape.

The operating principle of the project was that teaching goals would have priority over research goals. Activities that were of special interest to the project were described and teachers were requested to report when such activities took place in their classrooms. Teachers made special efforts to arrange their teaching schedules to make it possible for researchers to observe particular activities. Despite these special efforts, observers still needed to work around the needs of the teacher and constraints of the curriculum. The teachers were invaluable informants, highlighting activities that might have gone unnoticed if the observers had made unilateral decisions about observations.

Data Analysis. The teachers took part in discussions of the material to be collected, how it would be analyzed and participated in data analysis. The teachers collected samples of students work in language arts and

mathematical problem solving at regular intervals throughout the school year. For each of these samples they provided their guidelines for evaluating student work. Writing samples were scored according to the guidelines established by the teachers. Funds provided by NIE enabled the teachers to serve as Research Assistants during the summer after we gathered data in the classrooms. During the summer, the teachers participated in videotape viewing sessions. In these sessions they watched videotape from their classroom and worked with researchers to organize a coherent picture of classroom events. They collaborated in the preparation of some of the chapters in this report (see Chapters 3, 4 and 9). Three of the teachers will continue the analysis of materials gathered from their classrooms as part of an MA program at UCSD.

Summary

These are some of the ways in which a group of elementary school teachers and university researchers have worked together to seek effective ways to utilize microcomputers in schools, and to do so in ways that provide equitable access to all children. Observation of and participation in the implementation of these programs has provided us with valuable knowledge about the degree and kind of help students and teachers need to use computers in classrooms, ways to organize classrooms for instruction with computers, patterns of teacher-student interaction and students' learning. We report the results of this collaboration in the following chapters.

CHAPTER 2

THE CLASSROOMS

Marcia Boruta, Ann Marie Newcombe,
Marti TumSuden and Christina Drale

The research took place in four classrooms in the "North County" area of San Diego. The curricular emphasis in three of the classrooms was language arts. Therefore, we focused research attention on that area in those classrooms. In the fourth classroom, the teacher experimented with teaching problem solving using direct instruction techniques, manipulatable materials and computer programs. We documented the results of this experiment conducted in a computer lab and classroom.

The following pages describe the organization of instruction in the four classrooms. This overview is provided to orient the reader of this final report to the analysis which occurs in subsequent chapters.

The Organization of Barbara Miller-Souviney's 4th Grade Classroom

BMS' class was a fourth grade in which there were twenty-six students, thirteen boys and thirteen girls. The class was considered to be the fourth-year (mainstream year) of the school's K-3 bilingual program. Six students

(23% of the class) were past participants of this program. There were two aides in the class (funded by SIP and Chapter 1 funds): DT worked with all the children on both math and language arts in the morning. Another aide, MV, came four days a week for 45 minutes a day and worked on language arts with primarily the bilingual students.

The classroom was in a temporary building physically removed from the other, permanent buildings. The room was large and carpeted. BMS asked for the room particularly because she wanted an atmosphere that way away from other, "traditional" classrooms and the flexibility of the furniture arrangement that came with the temporary building.

Students were seated at four rectangular or circular tables. Students' belongings were stored in individual plastic tubs. BMS established this arrangement in order to accommodate both instruction and student seating in the same area.

The walls around the classroom contained charts and information that were used within the day's activities: a daily schedule, VIP of the week, spelling lists and typing paper, a daily class history, sustained silent reading directions, computer rules, a giant replica of an Apple //e keyboard made of styrofoam cartons, a height chart, calendar, "We Have Rights Chart," class groupings, and students' work.

The classroom was organized into activity centers. There are three centers called Station 1, Station 2 and Station 3 (see Figure 2). These were not additional areas but transformations of the students' seating areas, so

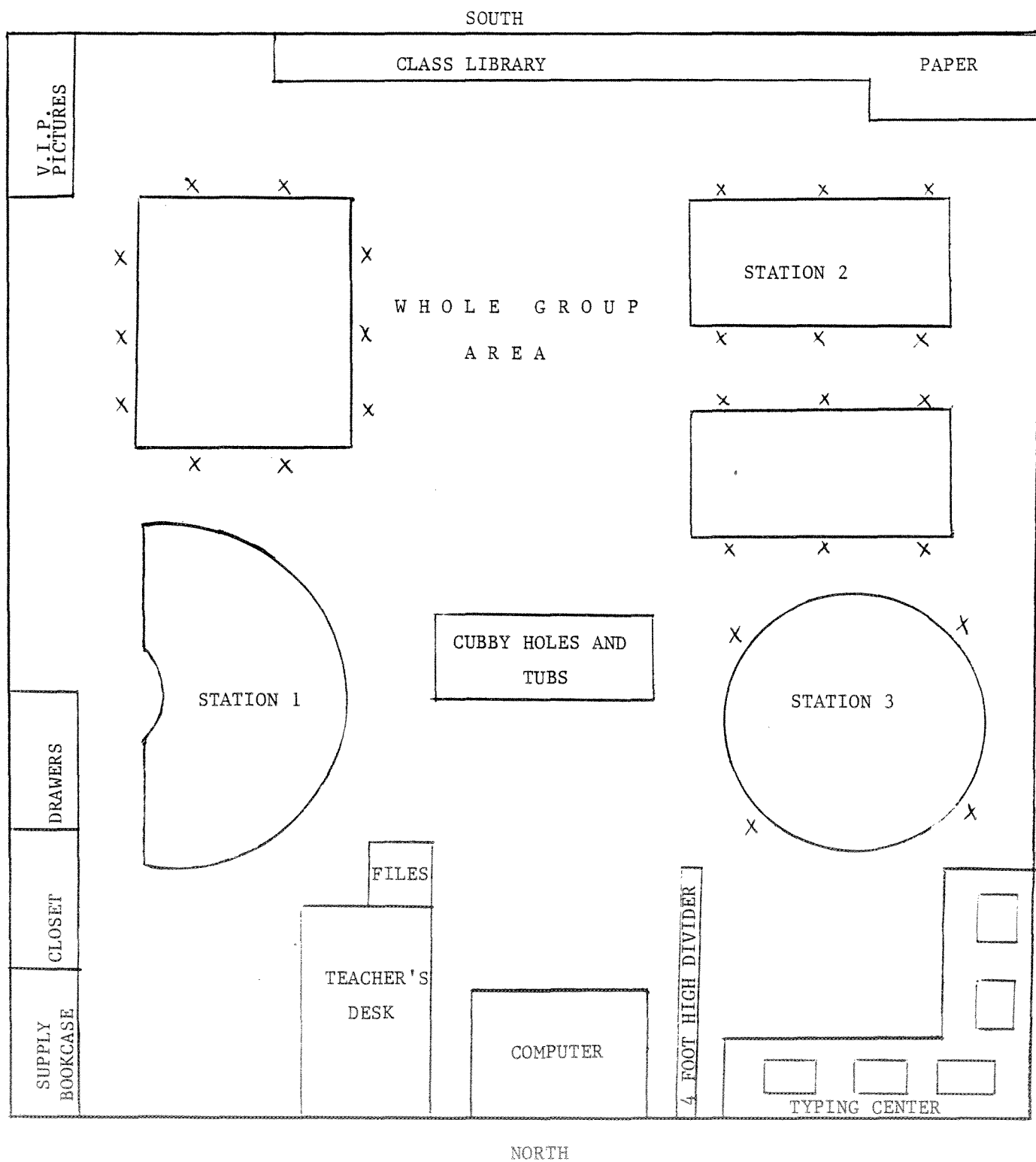


FIGURE 2
Olive School Classroom 4th Grade

that the kidney shaped table became Section 1, the rectangular table became Station 2, and the circular table became Station 3. The "computer center," where the classroom's one computer was located, and the typing corner (with five old typewriters) were a sub-set of Station 3. There was also a "whole group" area (the floor space in the center of the room).

The computer was located against the north wall of the classroom under the windows. It was on a moveable cart that contained all the necessary hardware and software: Apple //e computer, one disk drive, monitor, printer, and disks. It was somewhat isolated from the rest of the classroom by the arrangement of other classroom furniture (tub, bookshelves, teacher's desk, divider/display boards). Students working on the computer had their backs to the rest of the class. The area was fairly spacious, however, and the teacher could see the computer screen from her usual location at Station 1.

Students were placed into ability groups for language arts and math in the beginning of the year. Ability grouping was done on the basis of assessment tests that BMS administered herself, along with the recommendations of the previous year's teacher. Wall charts listing the students' names and the math and language arts groups were located above the blackboard. The scheduling and rotation of the students through the stations depended on these groupings which were flexible, and subject to change during the school year.

The Daily Schedule

7:30	School starts.
7:40-8:00	Whole group meeting in whole group area. This is the time for 1) News, 2) Things to Share, 3) Announcements, and 4) Questions.
8:00-9:00	Math. On Monday and Friday, whole class activities are conducted. On Tuesday, Wednesday and Thursday, the students rotate through the stations at 20 minute intervals. Monday through Friday, pairs of students are scheduled on the computer for 20 minute sessions.
9:00-9:30	Writing (pencil-and-paper). Whole group instruction that breaks into individual or small group work.
9:30-10:00	Nutrition and Recess.
10:00-11:25	Language Arts/Science/Social Studies. On Monday and Friday, whole class activities are done. On Tuesday, Wednesday and Thursday, the students rotate through the stations at 25 minute intervals. Monday through Friday, pairs of students are scheduled on the computer for 25 minute sessions.
11:25-11:40	Oral Reading. Teacher reads out loud to whole class.
11:45-12:30	Lunchtime.
12:30-12:55	Sustained Silent Reading. Students and teacher read silently.
12:55-1:15	P.E. (Physical Education).
1:15-1:30	Class History. Whole group activity. Students review what they did during the day. VIP of the week writes it on a 3x5 card that is placed on the Class History wall display.
1:30	School ends.

Writing Activity. Writing was an integral part of this teacher's curriculum prior to the initiation of this project in her classroom. This emphasis led us to concentrate attention on language arts when the computer

was introduced into the classroom. During the writing activity that took place from 9:00 to 9:30 everyday, students wrote with paper-and-pencil. The computer was not used during this time.

BMS' classroom instruction in writing focused on the writing process which includes the following phases: pre-writing, writing, response, revision, post-writing, and evaluation. The length of time it took to complete a writing project varied from one to four days and depended on the goal of the project. Writing for the development of fluency focused on pre writing and writing only, whereas writing for a class book or a class newspaper included all stages. During writing time, BMS either wrote along with the students or she walked around the classroom providing help as needed.

BMS initiated a writing project with the class as a whole. The class is called together at 9:00 to the whole group area where BMS introduced the topic and conducts a pre-writing activity. During the year, this included clustering words on the blackboard or a big sheet of paper, brainstorming ideas about content or titles, reading examples, drawing pictures, etc. Students returned to their seats to carry out a particular pre-writing activity, or, if sufficient time had been spent on pre-writing, the students began the writing stage of the process.

During the writing stage, BMS emphasized that they are writing only a first draft and they shouldn't worry about spelling or punctuation at this time; those issues were focused on during later stages. Students were given a certain amount of time to write (approximately 10-15 minutes) and a timer was set. Students wrote individually, but occasionally consulted BMS or

peers for help. During this time BMS wrote herself or helped students, for example, or wrote spelling words on the board.

When writing time was finished, BMS either collected the papers marking the end of the session, or, if time allowed, she asks for volunteers to share their stories with the class. She asked the rest of the class to listen to the story and think about what they like about it. Students were often eager to share their writing and BMS chose from a number of raised hands. After a student read his or her story, the other students responded informally to the writer regarding what they liked about the writing. Responding students were generally called on by the writer (or by BMS if the writer didn't seem to be doing it). The writer also chose the next person to share his or her writing.

The third stage, response, was also conducted in a whole group. BMS began the session by reviewing the phases of the writing process they completed thus far: clustering and writing. She then wrote a short segment on the blackboard of an anonymous student's paper. She asked how to make the segment "even better." Students raised their hands and were called on individually. They pointed out spelling errors, missing punctuation, or ways to make two sentences out of one long one. BMS showed how to make changes by correcting the segment on the blackboard: the change or mistake was circled so the writer knew what it was, or the correct spelling or punctuation was written on the paper.

BMS then divided the class into editing groups for response. Each table usually made up an editing group. She gave each table 3-5 papers with the

directions to read the story and edit it. Students read and edited individually. When a student completed one paper, they were to read another one, until they had read all of the papers assigned to his or her group. If the students had problems reading the writer's handwriting (which they often do) they were to ask the writer about the word. If they did know how to spell a word, they were to use the dictionary or ask a peer. During this phase, BMS walked around the room and helped or directed students to other resources. This phase of the writing process was characterized by a lot of peer interaction/consultation and walking across the room to the original writer. Once again, the timer was set for a limited amount of time for the editing process.

The fourth stage, revision, begins as edited papers were returned to the writers along with clean "white" papers (beige wood-pulp papers were used for the first drafts). Students rewrote their papers for the final draft. BMS reviewed revision guidelines which included assessing the editing suggestions that were made, consulting with the editor about the reason for particular corrections (if they were questioned), looking up spelling errors, and recopying the paper in legible cursive writing. Students worked individually at their tables, occasionally consulting peers or BMS as she walked around the room.

When the revision/recopying was complete, the papers were assembled in a public way for the post-writing stage of the process. They were hung on the wall in the classroom or put together in a class book. The whole writing process from the beginning to the end of a particular project usually took four or five days to complete.

Language Arts Instruction. Language Arts instruction occurred from 10:00 to 11:25 daily, but the structure of the activity varied according to the day of the week. On Monday and Friday instruction was generally in whole group form or a variation of ability groupings. On Tuesday, Wednesday, and Thursday, students rotated between the three stations in 25 minute intervals. The computer, however, was used daily by scheduled pairs of students for 25 minute intervals (duplicating station-rotation scheduling).

BMS prefaced the language arts period with a description of the introduction activities for the day. This introduction took place in the whole group area. It was particularly important for Station 3 where students worked independently. A thorough demonstration of the computer activity for the week took place on Mondays (and as necessary during the rest of the week). Students gathered together at the computer center for this demonstration. Before station-rotation began, BMS reviewed the day's computer assignment and, if a scheduled partner was absent, another one was chosen by the designated student.

Station Rotation: Tuesday Through Thursday. As mentioned earlier, the classroom was divided into three work stations. In general, Station 1 focused on reading comprehension activities with the direct involvement and presence of the teacher. Station 2 focused more on English, Science, and Social Studies activities. Activities planned by BMS were coordinated by the teacher's aide (DT). Station 3 activities focused on spelling and were independent of direct adult supervision. The computer activities (a sub-set of Station 3) focused on writing and were frequently under the observation

(although not the direction) of a project researcher.

Scheduling for station-rotation was established in the beginning of the year and was changed for curricular reasons during the year. Students were placed in three ability groups of approximately nine students each: Orange Group, Purple Group, and Green Group. Students' names were written on a sheet of appropriately colored construction paper and the lists were placed in a row above the blackboard (from left to right: Orange, Purple, and Green).

When station-rotation began at 10:10, the Orange Group went to Station 1, the Purple Group to Station 2, and the Green Group to Station 3. At 10:35, the teacher rang a small bell indicating the end of the first session. Students completed their activity and waited for the next bell to signal the next rotation. Students rotated clockwise around the room so that Orange Group went to Station 2, Purple Group to Station 3, and Green Group to Station 1 (refer to Figure 2). This cycle was repeated at 11:00, completing the rotation of all students through all of the stations.

There was also a schedule placed above the computer that indicated the pair of students to be on the computer during each 25 minute interval. Since the computer was a sub-set of Station 3, students were scheduled onto the computer when their group rotated into Station 3. Therefore, two students from each ability group used the computer each day.

Typical activities at Station 1 included use of the Weekly Reader, reading plays, poems, booklets, etc. BMS stressed higher level reading

comprehension skills such as inferencing and sequencing. Social studies were incorporated into language arts through such topics as safety and decision making.

Station 2 activities involved games or other manipulatives intended for practice with various English skills (for example, punctuation, capitalization, prefixes, vocabulary development, etc.). Station 2 was also used as a follow up to Station 1 (for example, answering questions pertaining to a particular reading activity in social studies and science), and as a seasonal "Holiday Station."

Station 3 activities focused on spelling and writing, including search puzzles, writing stories incorporating all the spelling words, or typing the week's spelling words on the typewriter. Section 3 activities were without the direct supervision of an adult and therefore required some special support materials. For example, on the bulletin board next to Station 3, there was a manilla folder for students' completed work, and another one for typing paper. There was also a paper for students to check off their names when they completed the given activity. Students usually worked on individual activities at Station 3. However peer interaction was abundant and in most cases encouraged (unless the noise level became too high, requiring teacher intervention).

The computer activities focused on writing. Students worked in pairs (which is unlike most of the classroom activities). Support materials giving directions were placed all around the computer: the primary note indicated the program/activity to be done for the week, step-by-step

directions on how to operate the word processing program, how to edit text, basic start-up and troubleshooting directions, posters with ideas for writing (pre-writing materials). Since the computer activities were also without the supervision of an adult, students had to solve any problems they encountered themselves, by referring to the support materials or by calling a peer or an adult for help. (There was frequently a research observer nearby who could provide assistance.)

Activities on the computer involved creating stories from pre programmed story parts, writing Computer Pal letters to students in a nearby school, editing poems that students have created, and writing newspaper articles for the Computer Chronicles.

When students completed an activity on the computer they were to print out three copies of the text (two for themselves and one for a file for the teacher). They then checked off their names from the Station 3 list indicating that they had completed the Station 3 activity.

Language Arts: Monday and Friday. Monday and Friday activities were basically whole group activities. BMS began the session on both days at the whole group area, going over new vocabulary words.

At approximately 10:20, students broke into their "Ginn Groups." These groups were similar to the Orange, Purple, and Green ability groups, however they specifically covered the classroom's five Ginn reading levels. During this time, BMS worked with Levels 10 and 11, DT worked with Level 8 and 9, and MV worked with Level 7. On Monday, students were given papers outlining

the week's Ginn lesson and related homework. Students began the lesson in their small groups and were to complete it for homework. The lesson included "Skilpak" activities for parents. This work was corrected on Friday during the same time period.

At approximately 11:00 on Monday, Spelling Super Star awards (stickers) were given to students who improved on the week's spelling tests. Following this, the week's spelling words were given in a pre-test. This was basically a whole group activity except for the Ginn Level 7 Group which took a separate test outside with DT. On Friday, a spelling post-test was given during this time period.

During this time, pairs of students were using the computer for 25 minutes. Special arrangements were made for them to complete missed work (if necessary) and get the week's assignments and spelling words.

Summary. This classroom was organized into small groups for the purposes of instruction, primarily small groups were used in all curricular areas, most notably those associated with language arts. Whole group activities appeared twice: once during the teaching of math, and once as a way to introduce language arts activities.

Some of the small groups were supervised directly by the teacher or aides; others were supervised indirectly. In indirectly supervised groups, students were expected to work independently on assignments that the teacher had given to them.

Computer activities were organized as a sub-set of one of the stations during language arts time. A pair of students went to the computer station and carried out instructions that were posted there in a manner analogous to the students who go to a station and work on an assignment independent of the teacher.

The teacher placed considerable emphasis on each student's responsibility for the group's welfare. A theme in her discussions with them and visible when she provided the rationale for or justification of her disciplinary action was: students taking personal responsibility for their actions. If students acted out or were disruptive, the teacher pointed out that their actions made it impossible for others to work, thereby making the entire group less productive. The teacher socialized the students into this norm both privately and publically. She attended to individual transgressions privately, out of the hearing of other students. On those occasions when an individual's or small group's actions had larger consequences, she called the whole class together as a group, and reinvoked the social contract.

The Organization of Bea Liner's 3rd Grade Classroom

Bea Liner's 3rd grade class at Palmquist Elementary School in Oceanside was an English/Spanish bilingual class. The classroom consisted of 30 students, although the number varied depending on the curricular activities (see Daily schedule). Of these 30 students, 10 were considered limited English proficient (LEP) students, qualifying for bilingual instruction. During our initial weeks of observation, from late September to November, Ms.

Liner placed a student teacher who was in training with her in charge of arranging the classroom environment. The student teacher organized classroom desks to form four main groups or stations. To the side of the four tables that formed the stations were a semi-circular table and a large round table where other curricular activities such as science exhibits were located. Within this arrangement the computer was placed against a wall, near the main classroom exit at the rear of the classroom, with the teacher's desk across the class in the opposite corner.

After the student teacher left, Ms. Liner rearranged the classroom into rows: four rows in back of each other, and at both sides of the classroom one long row extending from the front to the back of the classroom. Ms. Liner also moved the computer from its original position by the door to the opposite south-east corner, where the teacher's desk was located previously; i.e., at the front of the class where the teacher conducted most of her activities. Her desk was moved to form part of the long parallel row near the west wall of the class (see Figure 3, below). The computer is partially hidden and isolated from the rest of the classroom by a divider, which also serves as a display board for the computer users. It contained disks, instructions and other relevant information. From her usual position at the front of the class, the teacher had a clear view of the children working on the computer and was able to monitor any difficulties or problems, as well as encourage the students to stay on task.

Ms. Liner was assisted in her teaching duties by Ms. Delfina Zimmerman, a bilingual teacher aide. More than an aide, Ms. Zimmerman functioned as a co-instructor and participated fully in all classroom decisions and

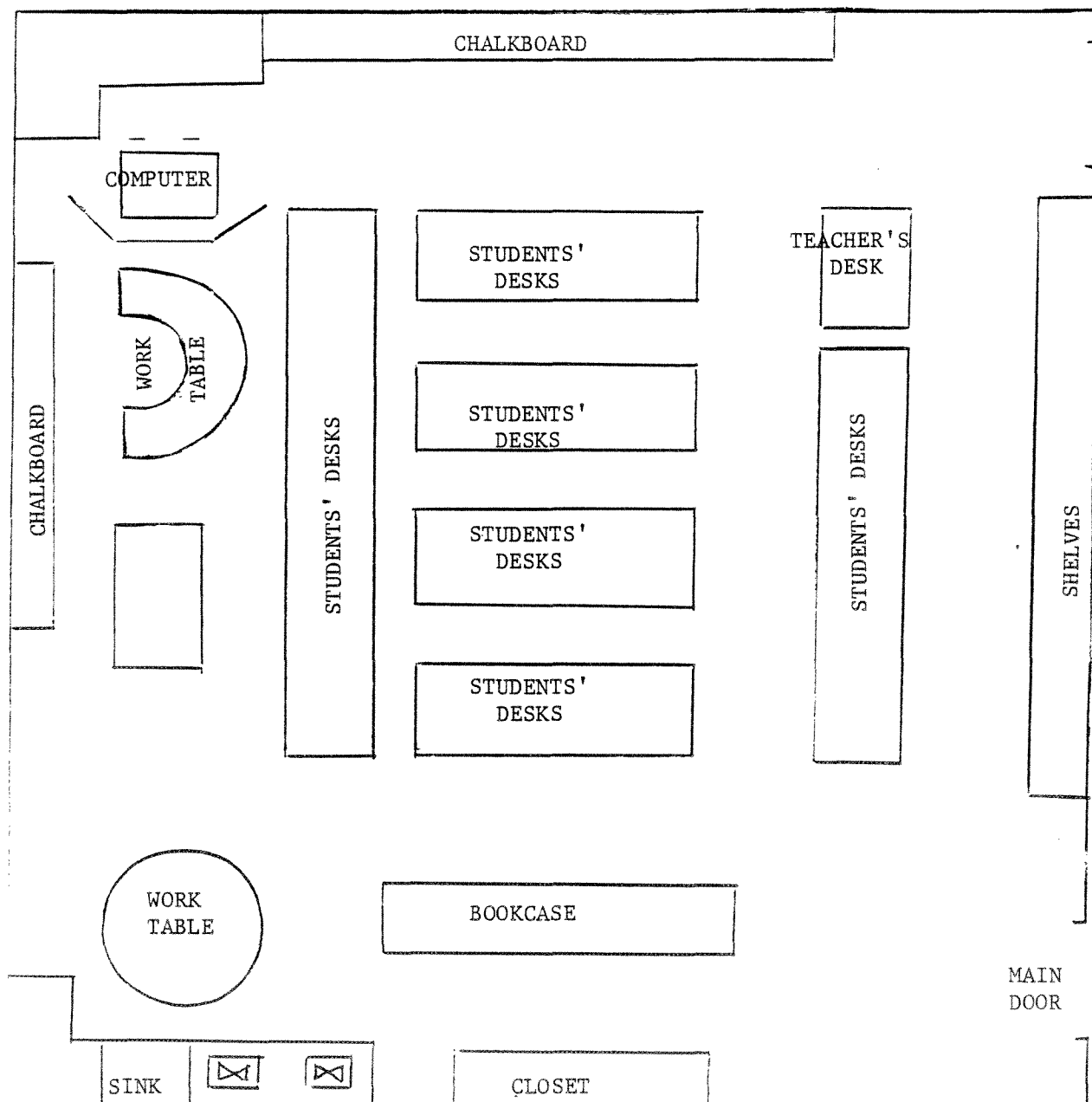


FIGURE 3
Palmquist School: 3rd Grade Classroom

activities. She arrived at nine o'clock in the morning and immediately took charge of the math, reading and writing lessons with the limited English speaking students. These lessons, which were planned jointly by teacher and aide, were organized into small group activities and conducted in a spacious, round table near the rear of the class. Occasionally, during the course of the day, Ms. Liner, also a fluent bilingual, monitored the lesson activities with the limited English speaking students, and offered suggestions to Ms. Zimmerman. Their emphasis was on team teaching. They met regularly after class to evaluate student progress and plan future activities.

While Ms. Zimmerman conducted her lessons, Ms. Liner taught whole-group lessons to the English monolinguals in the class. Ms. Liner attempted to maintain both groups of students on equivalent tasks. With the exception of the bilingual instructional support provided to the limited English speaking students, all students were exposed to a similar curriculum.

A computer schedule was posted weekly near the computer center. The children were assigned in pairs to use the machine for 30 minute intervals. Thus, each child in the class worked on the computer for at least half an hour a week. Every Monday morning, Ms. Liner described the computer activity for the week and her expectations for the students. She also provided examples of the procedures they were to follow, answered questions and addressed any complaints. The children learned this routine so the rotation of children to the computer proceeded smoothly.

The Daily Schedule. An unusual feature of this classroom was that

students are distributed by ability grouping among three different classrooms. For math instruction, Ms. Liner received children classified as high ability from two other classrooms while the children in her class not classified as such moved to other classrooms participating in this arrangement. A similar arrangement was made for reading instruction. In this case Ms. Liner received students classified as low group readers.

The classroom schedule is as follows:

8:30	School starts: roll is taken, assignments submitted, flag salute, etc.
8:30-9:45	Math time: the class composition consist of 20 English monolingual students, 6 Spanish dominant (LES) and 1 Chinese dominant student.
9:45-10:00	Recess.
10:00-11:30	Language arts, reading, spelling and writing: classroom consists of 22 English monolingual students and 10 Spanish dominant students.
11:30-12:15	Lunchtime.
12:15-1:20	Science unit/optional activities.
1:20-1:30	Recess.
1:30-2:05	Physical Education
2:15	School dismissed.

Mathematics. The math group (English monolinguals) consisted of students classified as high ability. Math instruction was organized as a whole group lesson. Ms. Liner stood in front of the class and provided directions, reviewed previous work, and introduced new content. She then provided the children with a series of problems to solve, usually in the form of worksheets. As the students worked on these problems, Ms. Liner moved

about the classroom providing assistance as needed.

Meanwhile, the Spanish dominant students, a much smaller group, worked on the tables to the side of the classroom under the supervision of the teacher aide. Occasionally the teacher came by the side tables to check on the students' progress and offered suggestions.

The math book used was Mathematics Around Us, California State Series, level 19-24. Some of the topics dealt with were addition, subtraction, multiplication, division, ratio, fractions and geometry. The Spanish speakers were using Mathematics, D.C. Heath & Co. These children worked on addition, subtraction, multiplication and rounding.

Language Arts. At the start of reading time, the English monolingual children classified as low readers entered the classroom. No such differentiation was made for the Spanish dominant speakers. More or less the same group of students remained in the class throughout the day. The same teaching arrangement described for math prevailed for language arts. Ms. Liner taught whole group lessons with the English monolingual speakers, and Ms. Zimmerman taught a small group lesson with the Spanish dominant students. The instructional plan for the Spanish dominant students included reading in Spanish (all of the students were reading beneath grade level), while they were being introduced to reading in English.

The entire school used the Ginn Reading Series. The English monolingual students were at Level 8: Give Me A Clue and the corresponding workbook. The Spanish speakers used the Santillana series in Spanish. They were at the

Adelante level. When reading in English they were at Level One of Ginn:

One Potatoe Two.

In addition to reading the students also worked on spelling, dictation and grammar. Ms. Liner introduced them to writing paragraphs. Every Friday the entire class wrote a short paragraph. For grammar lessons, the class used the McMillan English and the skills practice book that accompanies it.

Science and Optional Activities. The activities varied in the afternoon. Sharing time usually started off the afternoon activities. Children brought items or anecdotes to share with their classmates. This time slot was also used for science. They used a book called Concepts in Science 3. The children read silently a book of their choice for about 15 minutes. The children were later asked to discuss their reading with their classmates.

The Computer Corner. The children were introduced to the computer using a program called Apple Presents Apple. When Ms. Liner realized that students interrupted her often if something went wrong, she designated two students as "computer experts" to help other students who had questions or were experiencing difficulties. This strategy did not prove to be successful, as the students continued to rely on the teacher for help and rarely turned to more experienced peers. (This topic is discussed in more detail in Chapter 5.)

During the final week of October, Ms. Liner started assigning computer activities specific to math or reading and writing. For the most part, math

activities consisted of multiplication drill and practice exercises. During reading and writing children practiced spelling and used a program called Storyland to compare stories. This program was used in Spanish and English.

The Organization of Robert Rowe's 6th Grade Classroom

Mr. Rowe's sixth grade classroom, like Ms. Liner's 3rd grade classroom, was situated in a math-science magnet school. The magnet school was established as part of a voluntary desegregation plan. The students in this classroom were from diverse backgrounds. They had been identified as belonging to a variety of special education student categories: from the educationally gifted to those requiring extra assistance due to language or physical handicaps. The mixing of a diverse group of students in this classroom demonstrated an emphasis on mainstreaming and an egalitarian acceptance of students' differences on the part of the school and district.

This school incorporated ability grouping with the mainstreaming of special education students through the use of the homeroom concept. The homeroom represented a method of bringing diverse student populations together while ability groups separate students according to performance levels based on standardized tests. Two content areas, reading and mathematics, were organized according to ability groups. The students reported to their homeroom at the beginning of the school day before dispersing to other classrooms which have homogeneous ability groups.

In each grade the students were grouped into three levels within each

content area. The three teachers at a given grade level each had one ability group (level) rather than being assigned a heterogeneous student population within his or her own classroom. As a result of this policy, students changed classrooms, being responsible for taking the appropriate books, homework papers, and supplies with them. These rotations between classrooms occurred during the morning hours which were traditionally reserved for teaching reading and mathematics.

The Daily Schedule. The class schedule for this sixth grade was more structured in the morning (which revolved around group work) and more flexible in the afternoon (which allowed more individual study). Friday substituted a "study hall" for the morning math and reading hours. The daily schedule was:

8:30-9:00	Homeroom students (problem solving/journal writing. computer time for pairs activities).
9:05-10:00	Mathematics students (large group--computer time activities).
10:00-10:10	Recess.
10:10-11:10	Reading students.
11:10-11:25	Recess.
11:25-12:00	Homeroom students (journal writing/problem solving activities on computer).
12:00-1:00	Lunchtime.
1:00-2:40	Homeroom students (computer time for pairs). The school-wide goals for collective group and individual goals for the students are in evidence within this particular classroom.

Student Responsibility. This teacher emphasized responsibility to

oneself and to the group along with individual achievement. His students were expected to work during the allotted time in class and take home anything they did not finish as homework. Students showed various levels of task engagement; however, RR did not single out disengaged students unless their behavior disturbed others. Time was provided for students to work on assigned homework. On successive mornings students were expected to answer the roll call with the response "complete," if they finished and returned their homework, or "incomplete," if they had not. The teacher explicitly emphasized responsibility when the lesson included group work. RR pointed out that no one student should do all the work for the group; they should share ideas and think about the problem together. Group work was given sufficient class time with each day having a specific subgoal to be achieved. One objective implicit in the teacher's presentation of the group lessons related to the process of systematically outlining a project and attacking the project bit by bit. Each group was entrusted with dividing up the bits in any way they chose as long as it was equitable.

The Organization of Mathematics and Problem Solving Instruction. The focus of our research efforts in this particular classroom were mathematics and problem solving. In these two areas, this teacher used whole group instruction followed by small groups or pairs working cooperatively. Typically, the teacher presented a lesson to the entire group. He discussed the various skills to use to solve the problem or perform the mathematical calculation. After a discussion of this work, the students worked on the assignment with others. The students were allowed to move around the room in order to form work groups. Although students were encouraged to work with others, except on a few occasions specified as individual work, they could

choose to work on their own. Rare instances of behavior problems were solved by the teacher. He required the student to work independently, without the support and input of peers. This teacher had excellent rapport with his students and such disciplinary actions were infrequent. BR's teaching style was spontaneous, weaving the students' remarks into the lessons, often using their remarks to demonstrate the practical application of knowledge.

Originally the problem solving activity, which became called "the Problem of of the Week" opened the school day. The teacher dispensed with administrative details as quickly as possible and moved into the "problem of the week" without delay. This tactic worked well when the problem solving puzzles were relatively simple--i.e., without conditions which students freely interpreted in unique and unexpected ways. However, once the activity was established and the problems more complicated, the teacher felt this original time slot was too short and constrained the students' activity. The limited amount of time which remained after the necessary homeroom activities seemed to dampen the students' creative expression and increase their frustration. This constraint was resolved by moving the problem solving time to the 11:25-12:00 slot between the second recess and lunch.

Problem solving instruction focused on several skills: 1) understanding initial conditions; 2) understanding the manipulations required to arrive at a response; 3) visualizing--either concretely or abstractly--the problem and articulating that vision; 4) systematically representing this process-e.g., identifying patterns, predicting possible answers according to the pattern. These skills, often considered steps in the "scientific method," were

discussed continually as part of a method for achieving goals (or answers). Trial and error was an accepted method either because the student did not yet possess more sophisticated skills or because the problem did not lend itself reasonably to another method. However, the trials were to be ordered and recorded according to an articulatable criterion which lead more skillful students into "varing one thing at a time." Although the emphasis was on systematic problem solving, the activities were free flowing and not patterned according to predetermined steps. Students were encouraged to explore, think, create, and test their ideas rather than follow a rigid pattern of steps.

Classroom Layout. The classroom was located in a ranch style, single story school building in which some classrooms had a movable partition along one common wall. This classroom had a moveable divider along the east wall. The classroom on the other side of the divider had been transformed into a "computer lab." This teacher also had responsibility for this special resource room. These responsibilities included: organization of the lab, organization of the software, teacher in-service, cataloging software systematically according to types of curriculum objectives each program covers, and administrative duties--i.e., budget, ordering software and other computer materials, etc., presenting information to the district, parents, and other interested parties (see Figure 4).

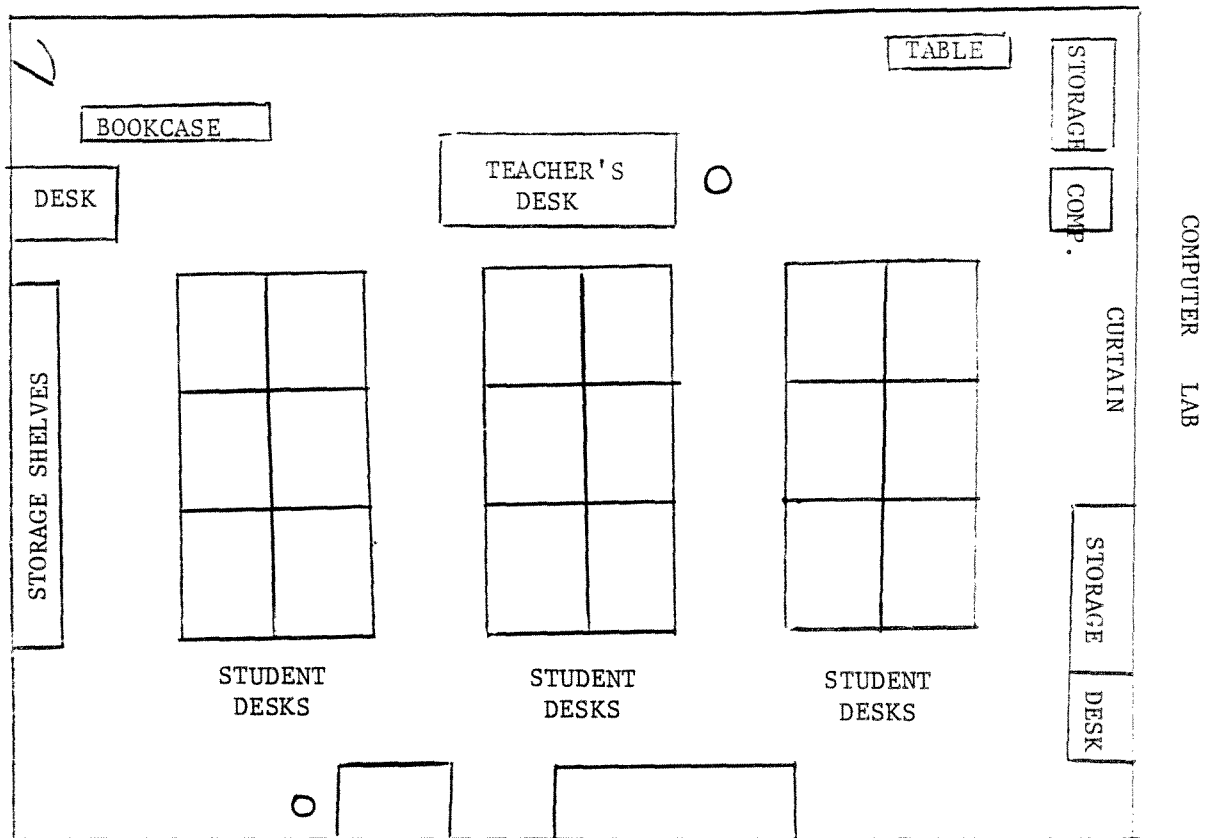


FIGURE 4:
Palmquist School 6th Grade

There were seven bulletin boards set up in this room:

1. Creative Computing
2. Art Work - "bark pictures"
3. Space Station

4. Word Wall
5. Mind Benders and Brain Teasers
6. Game
7. U.S. map

The left-hand corner of the black board, located in the front of the room, sported a bright yellow sign: Assignments. Under this sign were written the day's classroom and homework assignments.

The Computer Lab. This teacher had time allotted to him in the computer lab four times per week for 30 minutes. Occasionally, he utilized the computer lab for his class when it was empty during the math period. This math group was the lowest ability group and the students need practice at computations. The software available contained a number of computation and estimation programs which the students enjoyed along with a few they found uninteresting.

Summary. This teacher taught his class as a whole group, followed by individual work with students working alone or in small groups. Occasionally, the class was split into two large groups in order to accomplish two activities simultaneously. The groups spent one half of the available time on each activity. Lessons involving two activities were split spatially by using the computer lab next door as the second classroom. The focus of teacher-student interaction was on individual students. This focus fits the classroom emphasis on responsibility and the diversity of its students.

Students worked on the lesson activities after the large group presentation. During these work periods, the teacher and his aide assisted students by privately answering questions and giving encouragement. Public recognition was given to student ideas which served as models or clues (as the teacher called them) for others. The emphasis on responsibility and cooperation was evident during these work sessions. The teacher did not assign workmates or ways to divide up the task. The students were allowed these decisions. However, the teacher gave clues and publically recognizes students who discovered effective cooperative measures.

This teacher wove analytic problem solving skills throughout his lessons. Emphasis was placed on systematic approaches which produced results. Recognition was given to the trial and error method while introducing students to other approaches. Time management was stressed both as a student responsibility and as part of a systematic method for achieving goals. Lesson activities were discussed as whole activities and then as component activities. These component activities were implicitly organized in an adult fashion; but, the students are allowed to attempt them according to their own logic.

The computer lab represented an extension of this teacher's instructional style. Computer lab activities were presented to the whole math group before they entered the lab. Once in the lab, students worked individually or in pairs. The teacher or an adult aide was available to answer questions, make suggestions and guide the students. Students assisted each other whether partners or not by sharing ideas. The teacher brought good ideas to the attention of the whole group. The atmosphere in

the computer lab was cooperative--both towards humans and machines.

The Organization of Kim Whooley's 5-6th Grade Classroom

Garrison is an elementary school located in a growing middle class neighborhood in a southern area of Oceanside. Enrollment has increased 10.5% over the last year from 540 to 597. The school employs 21 faculty members with an approximate class size of 30 students each.

Ms. Whooley was the G.A.T.E. (Gifted and Talented Education) teacher for the 5 and 6 grades of the entire Oceanside district. Since G.A.T.E. was a district wide program, students were bussed in from other areas. Students were selected for placement on the basis of standardized test scores. If there were slots left over, they were filled with promising Garrison students and if at a later time new G.A.T.E. students were admitted, these students were supposed to be removed from the program. Ms. Whooley did not want to bump the Garrison students when this occurred so she had a class of 33 students.

The Daily Schedule. The school day began at 8:30 with a "class meeting." In the beginning of the school year, Ms. Whooley used this time to introduce the students to the expectations and routines of the classroom. As students became more adept at coordinating their own actions, Ms. Whooley used this time to discuss topics of current interest to the class as a unit.

The class meeting lasted approximately 30 minutes. This activity was followed by an hour of math instruction. After a twenty minute break for

recess, there were three periods of language arts instruction. When the recess bell rang, the students were led back to the classroom from the playground by their teacher in a single line not differentiated by gender, age or grade level. Upon entering the classroom, the students went immediately to a predesignated location and were generally settled by 10:35 which is the official beginning time for the first segment of language arts. The hour and forty minutes of language arts time was divided into four 25 minute periods. The teacher generally went to her predesignated location giving little or no instruction at this point.

The Organization of Language Arts Instruction. During each language arts period, a group of students was assigned to one of four activities: Reading Group, Writing, Seatwork, and Centers. Reading Groups worked during periods one and three and were therefore doubled up; that is, two groups worked together during a single period. Students formed a "reading group" with the teacher at the front of the class. While the official district reading program was the Ginn series, this teacher virtually replaced the Ginn reading program with one called "My Favorite Author." The class was divided into two groups; each group was assigned a novel to read. The teacher emphasized silent reading and reading for comprehension in this program. The teacher felt strongly that students should read complete works--stories, poems, books, rather than isolated segments.

A typical reading group was divided into phases. In the first phase, the students were asked general questions about their experiences with a topic that had been read or will be read in the next segment. The students were encouraged to offer personal opinions, interpretations, and provide

answers that diverged from any previous one. The teacher insisted that one student speak at a time, but access to the floor was voluntary--obtained by bidding or by nominations from the teacher. After a round or two of general discussion, the teacher oriented the students to the work they have been reading. The discussion turned to a link between personal experience and the events and activities being described in the book being read. Very little actual reading took place at the reading circle. Reading was assigned for seat work and for homework. When reading was done in the reading group, it was often to validate a point about the text or to support an interpretation being made about the text.

Writing and Seatwork. Writing and seatwork were both done at the student's personal desk. The writing activity for the day was written on the chalkboard. The general pattern involved students generating text based on topics provided by the teacher. Seatwork was a time for students to complete assignments, read assigned books, or library books, and do homework. Students were expected to work quietly and independently at their seats.

Centers. Center activity had another inner circle of organization. There were four centers at different locations along the edge or corner of the room. Each center had a unique activity associated with it. Center one started out as a typing center where students practiced specific typing tasks, and became a computer center. Center Two served a number of purposes: puppet plays, story recording, strategic games and library. Center Three was an art center for most of the year, although the form of art changed every week. The art form was often connected to a language activity by requiring a writing assignment about the art work at a later time. Center Four has been

a listening center in which students listen to a story on tape while reading along in a book, and a map making center which also involves listening to a tape. Students at this center listen to map information on a tape while filling in worksheets on map reading (see Figure 5).

There were eight students in each color group and eight students assigned to center work during each period. This means that there were two students at each center during each period. The scheme for determining which students went to which center each period each day is done in two steps. First, was students determine when they would go to centers by looking at the four-by-four matrix already mentioned. If a student observed that his or her color group was assigned to centers for the current period, he or she then referred to a four-by-eight matrix chart. The horizontal axis contained the four centers identified by number, and the vertical axis listed the names of the eight students in that color group--there was a different chart for each group. The student found his or her name and looked across to where a thumbtack has been inserted to indicate the center to which they were assigned. The thumbtacks were changed every day by the teacher. Each student spent one period a week at each center and generally received a new partner each time. In practice, it was only the researcher who had to continually refer to these charts; the students always seemed to know where they should be (see Figure 6).

The end of each period is signified by the ringing of a small hand bell by the teacher. When the bell rings, the students move automatically to their next assigned location.

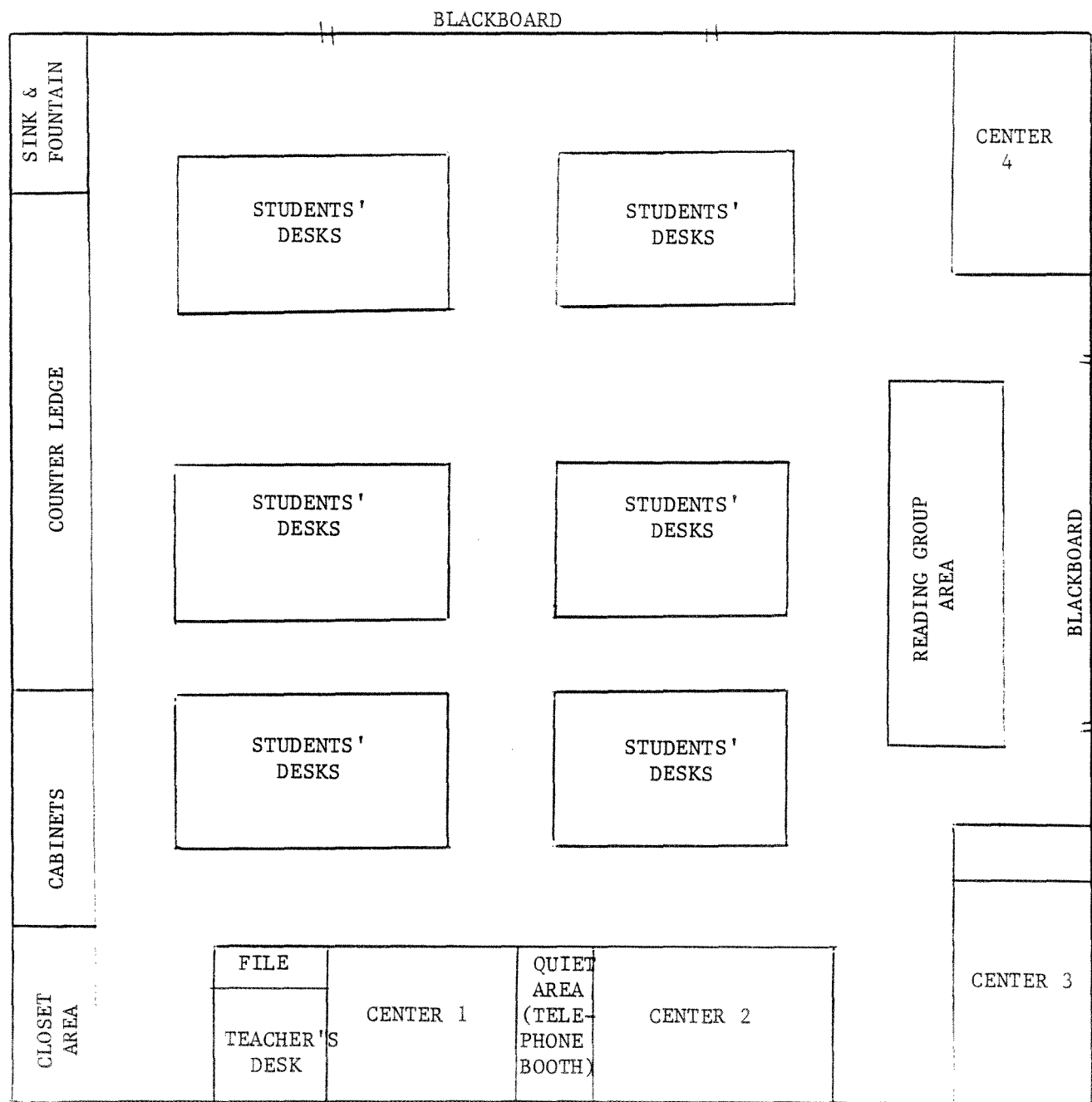


FIGURE 5
 GARRISON SCHOOL: 5-6 Grade

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	10:00-11:00	11:00-11:25	11:25-11:50	11:50-12:15
RED	GROUP	SEATWORK	CENTERS	WRITING
YELLOW	GROUP	WRITING	SEATWORK	CENTERS
GREEN	SEATWORK	CENTERS	GROUP	WRITING
BLUE	CENTERS	WRITING	GROUP	SEATWORK

RED

	1	2	3	4	
	•				CENTERS
			•		
		•			
				•	TACKS

[illegible][illegible][illegible]

The establishment of these practices in which the students had major responsibility for the organization of their learning was a significant goal for this teacher from the beginning of the year. She often commented to Drale and Mehan that she thought the students needed less academic instruction and more instruction about adopting individual responsibility. While it was the case that the rotation between groups and centers was smooth and seldom overtly directed by the teacher, considerable effort was expended in establishing these routines during the first few weeks of the year. The teacher did not start centers and small group instruction from the first day of class. She started with whole group instruction, emphasizing the need for individual student responsibility. After two weeks of coaching the students about seeking their own answers to questions, not seeking approval or sanction from her for each action, not asking her for validation or instructions, she introduced them to the centers and groups.

The introduction was accomplished in a fashion analogous to a stage rehearsal. The teacher literally walked the students through the group rotation, showing them where each group was to be at various times. For a week following the introduction of groups and centers, the students were given explicit verbal instructions at rotations. From that point on, the rotations took place without explicit verbal instruction. The students internalized the routine and followed it automatically. If the transition was particularly slow or noisy, the teacher added verbal cues or instructions. But from October 18, it occurred smoothly and quickly with students getting settled in less than a minute. During second and fourth period when the reading group was not meeting, three quarters of the students were at their seats. During this time, the teacher moved around the

room monitoring activity both at the centers and at individual desks.

Summary. Kim Whooley maintained a firm yet flexible pedagogical framework. It was firm in the sense that she insisted on certain procedural criteria, like following directions, but flexible in terms of the students' creative input. One of Ms. Whooley's highest priorities was to encourage students to assume responsibility for actions which were within their capabilities. She flatly refused to "spoon-feed" her students, forcing them to be aware of and use alternative sources of information like dictionaries, instruction sheets and other students, etc.

In addition to being encouraged to take responsibility for their learning, students were also encouraged to take responsibility for their creative expression. Ms. Whooley was very reluctant to prescribe ideas in any creative endeavor. If a student solicited her approval of an already formulated idea, she gave it, but if the student wanted to be given an idea or to have Ms. Whooley select an idea out of several possibilities, she would not do it.

Cooperation was also an important theme in this classroom. Not only the traditional requirement of teacher-student cooperation, but also cooperation between students. In some cases cooperation was an explicit part of an activity such as working at the computer center where a pair of students had to help each other accomplish a common task. In other cases, it is implicit in an activity such as when a student had to attain missed or forgotten information from someone other than the teacher. Students were expected to give help to anyone who asked for it.

These themes were combined with a very explicit spatial and temporal organization. With the exception of the students' personal desks, which they rearranged every month, the rest of the room was well defined and consistent. Centers and resource areas did not move. The time divisions were clear with a physical signifier at each transition, either a verbal cue or a hand bell. Each time period had a specific organization, but not necessarily a single lesson content.

CHAPTER 3

MICROCOMPUTERS AND CLASSROOM ORGANIZATION:

SOME MUTUAL INFLUENCES

Hugh Mehan

We are constantly being told that we are in the midst of a computer revolution. The computer is said to be the cause of changes in the organization of work, social relations, education, even the meaning of citizenship. Since microcomputers are becoming so pervasive in schools, it seems appropriate to look at the impact of microcomputers on the social organization of the classroom. We are interested to know whether the availability of microcomputers in classrooms has an influence on (a) the arrangement of the classroom and (b) the curriculum. That is, do 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.

The extent of the project teachers' knowledge about microcomputers and the manner in which they arranged their classrooms for instruction provided us with an opportunity to examine the impact of microcomputers on classroom organization. All four of the teachers in this project were expert teachers. But not all four were expert concerning the use of microcomputers. Two of the teachers, BL and KW, had not previously used a microcomputer on a regular basis, or had formal training in computer programming or computer use. Two of the teachers, BMS and RR, had extensive experience using

microcomputers but had not had them available for full time classroom use prior to this project. BMS had access to an Apple // for her classroom on a part time basis during the previous academic year, voluntarily led after school computer clubs and had taught classes on word processing through a university extension program. RR was in his third year of regular computer use. After using computers for math and language arts instruction in his classroom on a part time basis, he now had the additional responsibility for leading his school's computer lab. This project made a microcomputer available to him to use full time within his classroom.

At the beginning of the school year, that is, before microcomputers were introduced into the classrooms, there were two main systems of organizing classrooms for instruction. BL and RR used "whole group" arrangements as the primary mode of delivering instruction. BMS and KW used "learning centers" as the primary mode of delivering instruction.

The relationships among teacher's previous knowledge about computers and the manner in which they arranged their classrooms at the beginning of the school year are shown below:

Figure 7

<u>Teachers' Previous Knowledge about Computers</u>		
	<u>Expert</u>	<u>Novice</u>
Whole Group	RR	BL
<u>Classroom</u>		
<u>Arrangements</u>		
Centers	BMS	KW

We will discuss the relationship between microcomputer use and classroom organization under two headings: (1) the impact on temporal and spatial arrangements and (2) curriculum--what teachers teach and how they teach it. After our treatment of these topics in this chapter, we will discuss BL's classroom in greater length in Chapter 7, because of the unique combination of changes that took place there.

We are trading off the convergence of ideas from two quite different theoretical approaches to organize our observations. One of these theoretical approaches is called the study of "activity structures" and is associated with Bossert (1977) and Doyle (1978). The other is called the study of "participant" or "participation" structures," which was developed by Philips (1972; see also 1982), and has been used by Mehan (1979), Erickson and Mohatt (1982) Dorr-Bremme (1982), Florio (1978), Au (1980), and Moll and Diaz (1984).

Both approaches suggest that classroom activities can be described along a number of dimensions. These include (1) the size and the organization of the work group, e.g., whether the class is organized into one learning unit ("whole group" instruction) or is broken down into small groups or is

organized so that the teacher works with students on a one-to-one basis; (2) the task organization in the classroom (e.g., whether the whole class is working on a single task or small groups are working on many tasks simultaneously); (3) the response opportunities available to students in a recitation (e.g., whether students respond individually or in a chorus); (4) the response obligations (e.g., whether students are allowed to respond voluntarily or responses are obligatory); and (5) evaluation (e.g., whether evaluation of work is conducted in private or in public).

These dimensions of classroom life orient our description of the relationship between microcomputer use and classroom organization as well as our comparison of the structure of instruction when computers are used and instruction when computers are not used.

Impact on Spatial and Temporal Arrangements

There was no significant change in the way in which the teachers, BL, BMS, RR and KW arranged the space and used time in their classrooms as a result of having a microcomputer available for instruction on a full time basis. Both BMS and KW had used learning centers extensively in previous years. Both teachers used this spatial and instructional configuration when a microcomputer was made available to them by this project. BL and RR had used whole group methods of instruction in previous years; they continued to teach their classes in this manner when this project made a microcomputer available for their use.

The Inclusion of the Microcomputer into Existing Classrooms

Arrangements. BMS and KW injected the microcomputer into their on-going learning center arrangements. KW established a "computer learning center to complement her Art Center, Science Center, Map Center and her Listening Center. Students rotated between these centers, a teacher-led reading group and individualized seat work during the course of a morning's language arts work (see Chapter 2 for more details). In a similar manner, BMS used the microcomputer to complement her previously established methods of instructing reading and writing. BMS taught Language Arts to small groups within the framework of three activity centers (called "stations"). Three language arts ability groups rotated through the three centers four days a week. One station was devoted to reading comprehension activities, another was dedicated to reading in content areas such as Science or Social Studies, and the third to a variety of individualized activities. The computer was made a part of the third station and was used to enhance a number of activities taught in other parts of the Language Arts framework.

The structure of participation in both BMS's and KW's classroom varied with the activity being conducted. "Group work," in which students carried out teacher organized activities without direct adult supervision, was characterized by voluntary, student initiated participation. "Reading Group," in which students read and discussed texts, was more teacher directed. In a typical reading group, students were first asked questions about their experiences with a topic that had been read or would be read in the next assignment. The students were encouraged to offer personal opinions, interpretations and provide answers that diverge from previous answers. The teacher insisted that one student speak at a time, but access to the floor was voluntary. The floor was obtained by bidding or by nominations from the

teacher. After a round or two of general discussion, the teacher oriented the students to the work they had been reading. The discussion turned to a link between personal experiences and the events and activities being discussed in the book being read. Very little actual reading took place at the reading circle. Reading was assigned as seat work and for homework. When reading was done in the reading group, it was often to validate a point of interpretation being made about the text. "Writing" and "seatwork" were both done at the student's personal desk. The general pattern for the writing activity involved students generating text based on topics provided by the teacher. Seatwork was a time for students to complete assignments, read books from the reading group or do homework. During these times, students worked without supervision, at their own pace.

RR taught his class as a whole group followed by discussions and then seat work with students working alone or in small groups. The typical pattern of instruction was for RR to present material to the whole class and then engage students in a discussion. Students worked on the lesson activities after the large group presentation. During these work periods, the teacher and his aide assisted students by answering questions privately and by giving encouragement. RR placed the microcomputer against one of the classroom walls. Pairs of students were scheduled at the computer in 25 minute intervals throughout the morning. As each pair's turn came, they left the work they were doing and went to the computer.

BL responded to the availability of a microcomputer for classroom instruction in much the way that RR did. She arranged the students' desks into rows and primarily instructed her students as a group while they were

seated at their desks. She established a computer center against one of the classroom walls. At first situated by the door, she moved it to a location closer to her desk after 6 or 7 weeks of use so that she could monitor students' activities at the computer more effectively. The computer was partially hidden and isolated from the rest of the classroom by a divider, which also served as a display board for the computer users, containing disks, instructions and other relevant information. From her usual position at the front of the class, BL had a clear view of the children working at the computer and in other parts of the room. The children were assigned in pairs to use the machine for 30 minute intervals. Each Monday morning BL described the computer activity for the week, her expectations for their work and provided examples of the procedures they were to follow.

The manner in which the teachers set up computer center in their classrooms had consequences for students' learning. The teachers who used learning centers rotated all students through the computer center which meant that they were not removed from other classroom activities. The teachers who used "whole group" instruction, however, removed students from other activities to work at the computer center. As a consequence, they had to have students make up for the course work they missed while they were at the computer center. Rowe's solution to the problem was to make it clear to the students that it was their responsibility to make up for the work they missed while working at the computer. Liner used an elaborate schedule to provide students with opportunities to make up for missed work.

The Addition of a New Dimension of Participation: Dyadic Peer Interaction. 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. The teachers made these decisions for pragmatic and pedagogic reasons. Two students working at a computer increases, perhaps doubles, the total access time that a student has to the computer. Since each of the teachers in this project had 30 or more students and one computer, the logistics of organizing instruction limited the number and length of work sessions. By placing two students at the computer at one time, our teachers found that they could provide students with two 25-30 minute sessions a week, one devoted to math and one devoted to language arts.

Dyadic peer interaction was the new structure of participation 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 at the computer center. The teachers posted numerous sets of instructions around the computer. The first set gave students instructions with basic "boot up" activities. Supplementary instructions were added to give more specific instructions about each week's activities. 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 compulsory. 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).

Although the teachers did not monitor the students' work at the computer directly, incidental teacher evaluation was almost always present. As part of their regular travels around the classroom, teachers passed by the computer center. They often stopped and checked on students' work, offered suggestions, or were called upon by the students for help. Students working at the computer also called upon other students for help. These students gave instructions, and in the process, commented on students' work (see Chapter 5 for a more extended discussion of students' use of social resources at the computer center).

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 different from their experiences in other parts of the schedule. They often corrected each other's mistakes and cooperated in the completion of assigned tasks. Another consequence of

dyadic peer interaction was that it 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. We will discuss the cognitive consequences of peer interaction in more detail in the next chapter.

Impact on Curriculum

BMS, RR and KW 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 used in all phases of the writing process--pre-writing, writing, response, revision, evaluation and post writing. 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 Computer as a New Means to Meet Previously Established Curricular Ends. 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. For example, a poetry writing activity begun with paper and pencil 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 means to meet previously established educational goals. As we will discuss in detail later in this report (see Chapter 6), students writing using the word processing systems that are available on microcomputers facilitated the development of the students' control over the reading and writing processes. This improvement seems to have occurred, in part, because the screen editing and printing capabilities of microcomputer systems improved the production of students' texts by subordinating the mechanical details of writing (such as producing neat script, spelling and correcting errors) to the higher order goals of clear writing, fluency and the flow of ideas.

This statement should not be interpreted as a claim that word processors are responsible for improved writing, however. The computer by itself is not an agent of change. In and of themselves, word processing systems can not teach children to read and write. While we have found that word processing systems can not transform unskilled writers into skilled ones, they do have properties that enable teachers to make a new social organization for reading

and writing possible. It is this social organization and not the microcomputer that changed both what was taught and the way in which it was taught in the project classrooms.

Language arts instruction was organized with a microcomputer to establish "functional learning environments" (LCHC, 1982; Riel, 1983; Levin, 1982; Newman, 1984), i.e., those in which reading and writing are organized for communicative purposes. It is at this juncture that the microcomputer moves 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 Computer as a Means to Meet New Curricular Goals. We extended the work of Riel (1983) and Levin et al. (1984) by establishing functional learning environments using the student newswire service known as the "Computer Chronicles" in the project classrooms. The Computer Chronicles Newswire is a network that currently connects students from Alaska, California, Hawaii and Mexico. Students from each of these locations write and edit articles stored on floppy disks. The disks are sent to all sites participating in the network. Students at each site use the articles they have written as well as ones written by students in the network to produce their local editions of the Computer Chronicles newspaper. The network was explicitly modelled on the international news wire services. Whenever possible, students' attention is focused on the parallels between their work and the work of newspaper editors and reporters.

The Computer Chronicles helped the teachers establish learning

environments that were functional, i.e., reading and writing 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 making the Computer Chronicles a functional system for reading and writing. Having an audience with which students were unable to communicate verbally, but with which they wanted to share ideas, gave 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 (see Chapter 6 for a more extensive discussion of changes in students' writing as a consequence of participating in these functional learning environments).

When the students realized that other people would read their work for the information they provided and not just to evaluate its form, they took control of their writing. They engaged actively in revising and editing their own writing and the texts of their peers. After students wrote and edited their articles for the Newswire, the articles were submitted to a local editorial board for consideration. If the local editorial board, composed of five to eight students, accepted the article, then it appeared in the classroom newspaper and was read by the author's family and friends. Articles were also sent over the newsire to other schools, where other students reviewed their work and decided whether to include it in their local newspapers. If accepted in these remote locations, then not only local peers, but people in Alaska, Hawaii and Mexico read the work. This goal of writing for an audience was extremely effective in motivating both reading and writing.

Summary and Conclusions

In this chapter, we have considered whether the availability of a microcomputer for day-to-day instruction in classrooms affects the way in which teachers arrange their classrooms, and modifies what teachers teach and how they teach.

While there is no doubt that there are widespread changes associated with the microcomputer in the world of work and education, our research in the classroom suggests that it would be inappropriate to conclude that the computer, in and of itself, is a causal agent of change. When used in educational settings, the microcomputer is always a part of a larger social system, which includes the students, the teacher, their history of past relationships, the history of ways of teaching, the history of ways of organizing classrooms, the relationship that the classroom curriculum has to to the classroom surroundings, and the relationship between the classroom and the school, community and agencies beyond.

There was no significant change in the way in which the teachers arranged the space and used time in their classrooms as a result of having microcomputers available for instruction on a full time basis. The microcomputer was incorporated into previously established practices for organizing instruction. Teachers who used learning centers previously did so again when microcomputers became available. Teachers who typically taught their classrooms as a whole followed by discussions and individual seat work continued to do so when they had microcomputers. This pattern was the same

regardless of the teachers' previous knowledge about computers.

The absence of changes in temporal and spatial arrangements that we observed when microcomputers were introduced into classrooms shows how resilient that classrooms are to attempts to change (Sarason, 1982; Cuban, 1983). If the results of our modest investigation are replicated in other school settings, then we would 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 did not modify existing spatial and temporal arrangements, the availability of a microcomputer added a new participation structure to the classroom. Teachers placed two students together at the computer. Peer interaction emerged from this arrangement. Students worked together at the computer without direct adult supervision. They were left to their own devices to sort out the manner in which tasks would be completed. While students were responsible for completing their assigned work at the computer, the students worked out the details of task completion themselves, resulting in voluntary not compulsory forms of instructional activity. Since the teachers did not monitor the students' work at the computer directly, their work was evaluated privately not publically by the teacher. As a consequence of this change in participation structures, students developed a different sense of social relations. They assisted each other at the computer and cooperated in the completion of assigned tasks.

Microcomputers also had an impact on the curriculum in these

classrooms. They served as a means to meet previously established educational goals, and they provided a means through which previously unattainable goals could be reached. The teachers used the microcomputers to create functional learning environments in which reading and writing was arranged for communicative purposes. The "Computer Chronicles Newswire" gave students a reason for writing: to share ideas and concerns with other students with whom direct interaction is not possible. The public nature of writing provided motivation for re-writing and editing, giving students increased knowledge of educational technology.

The teachers' connection to the student newswire service enabled them to achieve important educational goals, goals that they could not have achieved as readily had a microcomputer not been available for their use. Students from different countries were able to interact via microcomputers and telephone lines and participate in joint problem solving activities centered on instructional issues. As a component in a unique electronic communication system, the microcomputer has the potential to help teachers address important curricular objectives. While students are developing their skill in using the computer for word processing, they are being placed in contact with students from different cultural backgrounds. In the context of gaining experience in communicating across cultural and linguistic boundaries, teachers and students are provided with the opportunity to gain understanding of the norms and traditions of different cultures and to thereby increase understandings of their own cultural norms and traditions.

In short, the microcomputer was accommodated into existing classroom organizational arrangements, but was associated with changes in teacher-

student relations and curriculum. Therefore, we are led to dismiss accounts which say that classroom culture will dictate the organization of classroom computer use and to dismiss accounts which say that the availability of microcomputers will cause wholesale changes in education. At this point in our investigations, we are more inclined to adopt an account that characterizes the relationship between classroom organization and computer use as a mutually influential one.

CHAPTER 4

SOME COGNITIVE AND SOCIAL BENEFITS OF PEER INTERACTION ON COMPUTERS

Hugh Mehan, Nick Maroules and Christina Drale

For the reasons we described in Chapter 3, each of the teachers in our study decided to have two students work at the computer at one time. The teachers' decision to place two students rather than one student at the computer enables us to ask the following question about computers in classrooms:

Do students working together receive cognitive and social benefits from their interactions?

The cognitive issues that arise from peer configurations at the computer concern the relationship between learning in social situations and learning in individual situations. Simply stated: are social learning situations productive? Do pairs of students working together get their work done, or does their attention get diverted from assignments?

While there have not been many studies that directly compare learning in group vs individual situations at a computer (the exception is (Trowbridge and Durnin, 1984), there are studies which suggest that there may be benefits which accrue to students working together that do not accrue to students working alone in studies of peer learning. Vygotsky (1978) discusses learning situations in which more knowledgeable people assist less knowledgeable people until the less capable are able to take over the task. In this way of thinking, knowledge proceeds from the

social to the psychological, as individual learners internalize the teachings from representatives of the larger society.

Observers of students teaching students (Steinberg and Cazden, 1979; Mehan and Riel, 1981; Riel, 1982) find that peers make suggestions, model and demonstrate activities to each other. Studies of "cooperative learning" situations (Webb, 1982; Slavin, 1983; Kagan, 1984) [in which a classroom of students is divided into small teams whose members are interdependent] show students improve in academic achievement, interethnic relations and pro-social development. These gains are especially prevalent among sociocultural minorities.

Verbal interaction is a potentially important mechanism in these situations, because students working together talk out loud to each other. The act of verbalizing material is thought to lead to cognitive restructuring on the part of the students who are attempting to explain. Verbal interaction is also important because it leads students to hear different points of view, which, in turn, can lead to cognitive conflicts. Cognitive conflicts are important, it has been argued, because it forces learners to examine their own understanding, and to seek resolutions of conflicting viewpoints (Piaget, 1971).

Background Information

Before assessing whether there are cognitive and social benefits of peer interaction at the computer, we will provide some background information about the organization of a work session at the computer and

the design of the software employed by the teachers.

The Phases of a Computer Work Session

A given work session at the computer can be thought of as a "lesson" because it has many of the elements of classroom lessons described previously (Mehan, 1979; Shuy and Griffin, 1978; Erickson, Schultz and Florio, 1982). One of the points of similarity which is important for our purposes concerns the sequential organization of the work activity. A work session at the computer has three "phases": "a start up" phase, an "academic" phase, and a "wrap up" phase.

The start up phase is concerned with initial machine operations. Students select a disk from the library of discs available to them near the computer, insert a disk into the disc drive, turn on the machine, move disks around, call up the menu, select the program from the menu. The nominal academic phase places the students in interaction with the program selected. We say "nominal" academic task here because previous research (e.g., Hood, Cole, and McDermott; Mehan, 1980; Riel, 1982; LCHC, 1982) has pointed out time and time again that students' definitions of situations do not necessarily match teachers' definitions of situations. As a result, we make the principle of multiple definitions of situations an operating tenet of our research. The wrap up phase is the mirror image of the start up phase. Students leave and update their program, print their work, remove disks and return them to the library, turn off the machine, and leave the work station.

Software Design

The software that our teachers used for language arts can be placed along a continuum from those that provide a great deal of support for composing text to those that provide very little support. The computer does most of the work at the supportive end of the continuum, and students must do most of the work at the minimal support end.

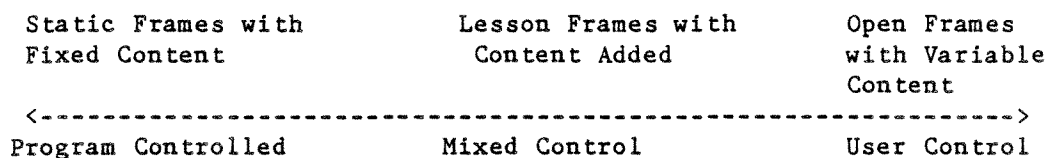


Figure 8: A Continuum of Educational Software (from Riel et al., 1984)

The prompts at the most supportive end of the continuum are program controlled. They are organized as static frames with content that does not vary. Information appears as fixed choices, analogous to multiple choice questions. Students produce a text by selecting between alternative wording in the texts and by choosing different branches or story episodes. The prompts of the software at the next step on the continuum provide a mixture of control between program and user. Students are asked to fill in words and phrases as well as make choices among predetermined options. As students increase their writing skills, more and more of the writing activity is taken over by the students. The next phase shifts control from the program to the user by having students work within open frames in which the content of students' work can be varied. Students enter their own sentences in response to specific prompts.

Finally, students produce complete texts on their own.

This continuum of support will be illustrated by reference to a set of interactive texts called "the Expository Prompt." Developed by one of the teachers in our study (Miller-Souviney, 1985), this software was used by the teachers in our project in sequence from program control to user control.

Here is an example of the Expository Tool at the program control end of the continuum. Students choose among fixed options presented by the computer program when creating an essay about making a sandwich:

SANDWICH PROMPT

Today is

1. Saturday
2. Martin Luther King Jr.'s Birthday
3. Teacher's Workshop Day
4. National Take a Computer to Lunch Day

(Choose 1...4; 0 to exit);
(Type a number then push return)

and I have a day off from school.

My parents are

1. at work
2. climbing Mount Everest
3. eating at a restaurant
4. playing tennis

(Choose 1...4; 0 to exit);

(type a number then push return)

so I have to make my own

1. breakfast
2. lunch
3. dinner
4. snack

(Choose 1...4; 0 to exit);
(type a number then push return)

(etc.)

After students gained familiarity with choosing among fixed options, the teachers moved to the next phase on the continuum. Here is an example of a mixed control program. Students add the content to the frames provided by the program to make a story about a "School Day Schedule":

SCHOOL DAY SCHEDULE PROMPT

The name of my school is

?

(Type, then push CTRL-C when done)

It is in the town of

?

(Type, then push CTRL-C when done)

I am in grade

?

(Type, then push CTRL-C when done)

and my teacher's name is

?

(Type, then push CTRL-C when done)

I have a very busy schedule at school. My class does
all sorts of things to make it fun to learn.

(etc.)

This "School Day Schedule" prompt provides students with the
beginnings of sentences and paragraphs and invites students to complete
the ideas begun for them by the expository prompter.

As the students increase their writing skills, the teachers moved
them further along the continuum toward user control. In the third expository
writing task, the students are presented with the topic of "how to run a
computer." Topic sentences for each paragraph as well as reminders of what
is contained in each paragraph are provided. Students enter their own
sentences which become the introduction, body, and conclusion of their
essay.

HOW TO RUN AN APPLE COMPUTER

We are lucky here at Olive School. We have Apple
computers. We use them to help us practice our
spelling and math, write stories and lots of other
things. An Apple computer is easy to run. Just
follow these simple directions.

First, it is important to know the different parts of
the computer and what each does.

(Write complete sentences telling the parts of an
Apple and what they do.)

?

(Type, then push CTRL-C when done.)

Next, to start the Apple, several switches need to be
turned on.

(In complete sentences, describe where each switch is
and what it does.)

?

(Type, then push CTRL-C when done.)
etc.

In the final activity in the expository writing series, students are presented with "How to..." topics to write about, but little in the way of supporting instructions. Students are now responsible for producing complete texts on their own.

HOW TO PROMPTER

Think of something you know how to do that you could explain to a friend about. For example, you may know how to wash dishes, run a computer or clean your room.

Remember:

- 1) The first paragraph is your introduction and will tell something about the activity.
- 2) The second paragraph will tell the steps it takes to do it.
- 3) The last paragraph is your conclusion and can tell about how you feel when you finish the activity or when you will do it again.

Throughout these activities, the educational goal is for the quality of the writing to remain constant while the degree of the participation of the learner increases, concomitant with a decrease in the degree of support provided the computer.

The Division of Labor in Computer Operations

The circumstances at the computer center are complex. An academic task

is presented to the students, the goal or end point of which is specified (e. g., edit a letter, write an expository essay), but the means to reach that goal and the manner of completing the task are not specified by the teacher. Faced with the challenge of figuring out how to carrying out the teachers instructions, it was possible that one student would dominate the encounter and perform the entire task alone while the other student watched passively and helplessly. We did not find this kind of imbalance, however. Like Levin, Boruta and Vasconcellos (1983) before us, we found that the students cooperated to complete the tasks at the computer. We did not observe any work sessions in which one member of a pair performed all operations and the second member of the pair did nothing. Thus, a division of labor is one consequence of placing two students together at a computer for the purpose of accomplishing academic tasks.

Diversity in the Division of Labor

While students divided up the assigned task in each and every computer work session, they did not divide the task in the same way upon every occasion. The procedures that the students used to divide up the task ranged from those which had a sequential quality to those that had a parallel quality.

Sequential Processing. Sequential processing occurred when students divided up the task into units and took turns, each student performing all the actions necessary to complete that unit. Once a student had completed his or her turn, s/he turned the keyboard over to the other student.

The turn units varied in size. The smallest unit was a single key stroke e.g., entering a letter or a number in response to a prompt from a "forced choice" computer program, or pushing a return key. Turn units of intermediate size included a sequence of key stroke-return key combinations or a string of text. The largest turn unit was a complete text. When writing a complete composition, a student made all the choices necessary to complete a poem or a story in response to prompts from the computer program (e.g., Sandwich Prompt, Science Fiction Story or How To Run an Apple Computer).

The following example is representative of those in which the task is divided sequentially, i.e., one student completing a turn is followed by a second student completing a turn. In this example, the students have been asked to write a science fiction story. The software is at the "Program Control" end of the software continuum (see Figure 8), i.e., students make choices from a menu of selections presented to them on the monitor:

Example #1 [BMS classroom; Oct. 6, 1983; students writing
writing stories with "Science Fiction Story Maker"]

<u>Turn</u>	<u>Ss</u>	<u>Action</u>
-------------	-----------	---------------

- | | | |
|---|------|--|
| 1 | M,S: | What is your name (reading from monitor) |
| 2 | S: | Me first (begins to type) / Ok first we'll do my name/ Return |
| 3 | M: | (presses return key) (makes selection, presses return key) /
makes selection, presses return key) |
| 4 | S: | I get to do (makes selection) / Your turn |
| 5 | M: | (presses return key) |
| 6 | S: | (makes selection, presses return) / Your turn |

7 M: (makes selection, presses return)

8 S: No

9 M: (makes selection, presses return) / (presses return)

(BMS 9; Oct. 6, 1983)

The first few exchanges between the students in this work session were characterized by considerable competition for a turn to respond to a prompt (see lines 1-4). There were also frequent shifts in the length and duration of a student's turn in interacting with the computer. Table 1, below, summarizes turn units and order for the turns in which students made entries during this work session.

Table 1
Summary of Turn Units and Order BMS9: First Story

<u>Turn</u>	<u>Student</u>	<u>Unit</u>
2	S	name
3	M	return key/selection key/ return key/selection key/ return key
4	S	selection key
5	M	return key
6	S	selection key/return key
7	M	selection key/return key/ selection key/return key/ return key
9	M	selection key/return key

While we have the "ab,ab" alternation which is so characteristic of naturally occurring conversations (Sacks et al., 1974) and classroom lessons (Mehan, 1979), we also have units varying in size from a single press of the

return key (turn 4) to a sequence which involves multiple selections (turn 6). In addition to the variability in size and duration of turn units, the first stories that students wrote at the beginning of the school year were often characterized by considerable competition among participants in an effort to establish ownership of valued resources, e.g., the computer keyboard. Consider the following story written by A and B:

Example #2: [BMS' classroom; Oct. 4, 1983; Students were writing
writing stories using "The Science Fiction Story Maker"]

Turn Ss Action

1. B: What is your name, what is your name?
2. A: (enters text)
3. B: (makes selection)
4. A: I get to do the next one, okay?
5. B: I get to pick though, I get to pick though
6. A: Uh uh. You do one and I do one
7. B: Okay, giant giant
8. A: (makes selection)
9. B: No tiny tiny / no wait. Okay, now I get to pick
10. A: No, you do this one
11. B:
12. A: Yeah okay, you do this one
13. B: (enters selection)
14. A: And I do the next one/ Return/ Now I get to do the next one
15. B:
16. A: (makes selection)

17. B: No
18. A: I get to pick, now you get to pick which one
19. B:
20. A: Go
21. B: (makes selection)
22. A: Now I get to pick the next one/ (makes selection)/ Now I'm going to pick two. Yesterday's was stinky.
23. B: (makes selection)
24. A: (makes selection)
25. B: No/ (makes selection)
26. A: (makes selection)
- (BMS 3: Oct. 4, 1983)

In this sequence, A is vociferous in his attempts to allocate alternating turns every time the computer provides a prompt. We can see at least eight specific actions on A's part in this effort, (see lines 4, 6, 10, 12, 14, 18, 20 and 22), which suggests that students attached a high value to a limited resource--access to the computer keyboard.

By making selections from a menu, students were able to create between five and nine stories in a 25 minute working session. By the time students had created three stories together, they discarded small units (e.g., keystrokes) and negotiated the "story" as the turn-taking unit. The systematic nature of this shift from turn-units of small to large size became even more evident as students wrote more and more menu-driven stories together.

The systematic shift from small turn-units to large turn-units also

illustrates the multiple definitions of the situation, which in turn, reinforces the need to talk about the academic task in nominal terms. While the teacher had defined the goal of the academic task in terms of students gaining practice with hard and software and producing complete stories with the aid of the computer, the students often saw this activity differently. For many, it became a session in which to produce as many and as silly stories as was possible. This alternative definition of the work session sometimes resulted in frantic key pressing and story printing.

Parallel Processing. Parallel processing occurs when students divide the task into actions such that one student is responsible for certain types of actions and the other student is responsible for other types of actions. In general, one student took responsibility for entering text, while the other student took responsibility for monitoring the text entry. The student who adopted the monitoring role made suggestions about story content and corrected mistakes in machine operations. This "in-process editing" of stories and poems included modifications of language mechanics such as spelling and grammar and those concerned with more global issues such as the overall organization of an essay and coherence among sentences.

The following exchange is an example of parallel processing in which student R does all the key entry while student S contributes in process editing:

Example #3: [KW's 5-6th grade classroom, Dec. 1, 1983; students were editing a letter previously written by the teacher using the Writer's Assistant Text Editing System]

Turn Ss Action

S: Do you think we should put a comma there?

R: I don't know. First of all we've got to drop the whole word.
S: Yeah.
R: Morning. ...Where's drop? Drop.
S: Then...
R: All right, we drop one more so that that gets erased, and then
control-C.
S: And then you push in.
R: Input.
S: M-o-r...
R: Okay, m-o-r-n-i-n-g, good morning, and then...
S: Control-C
R: Um, no, I think we should put a, a what's it?
S: Exclamation?
R: Yeah, exclamation...

[KW #11, Dec. 1, 1983]

Notice that the task is no longer a series of turn units, but rather a single unit with shared responsibility. Student S asks, "Do you think we should put a comma there?" (turn #1). Student R answers "We've got to drop the whole word" (turn #2). This is very different than the "I" and "you" language in Examples 1 and 2. This pronominal usage marks the shift from single production to joint production in the students' work.

In the next exchange, the division of the task into two parallel processes is more pronounced as student X does all of the key entry while student Y suggests the content.

Example #4: [KW's classroom April 26, 1984, students were assigned
to write a newspaper article using the Computer
Chronicles Prompter]

<u>Turn</u>	<u>Ss</u>	<u>Action</u>
1.	Y:	What is this?
2.	X:	I don't know. [X does key entry] That scares me when it does that.)
3.	Y:	Okay, that's it.
4.	X:	Okay, let's think about this.
5.	Y:	Uhm, let's look at things to write about. [Y looks at posted list of things to write about] Uhm, I know.
6.	X:	What?
7.	Y:	Let's write about the book club...Tom Sawyer, Tom Sawyer?
8.	X:	Wait, wait, let me look at this ((pause)) okay, we'll write about the book club.
9.	Y:	What?
10.	X:	We'll write about the book club.
11.	Y:	Let's see what we've got...news.
12.	X:	Or would it be fun; no, news.
13.	Y:	News.
14.	X:	School news.
15.	Y:	School news.
16.	X:	Uhm, do we have a headline? ((pause)) Garrison book, Olympic book, Garrison salutes the Olympics, uhm Garrison book club?
17.	Y:	No, Garrison Olympic book club. Okay? Garrison Olympic book club. ((laughter)) I feel like I'm being wired. [referring to the video equipment]
18.	X:	((laughing)) I know. Okay, we do have one.
19.	Y:	Garrison Olympic book club. [X enters headline.]

20. X: I feel like your secretary kind of. ((laughs))
21. Y: [In an affected tone] Please type this, please send this letter in please.
22. X: I know, I love to type. ((pause))
--I'll do all the typing, I like to type.
¶
23. Y: --() right in my face. [referring to the video equipment]
It's kind of uncomfortable. ((pause))
24. X: Garrison...
25. Y: Garrison, I'll write it in.
26. X: Olympic book club.
27. Y: I know.
28. X: I'll type it all in.
29. Y: ((sigh)) (says name of partner)
30. X: B, b, okay. [X continues to do all key entry] And then shift.

[KW #19, April 26, 1984]

This example demonstrates the importance of role in parallel processing. Each student has different responsibilities throughout the entire task and any infringement of role responsibilities bring sanctions from the other student. The division of labor is not rigid, however. This example shows that students negotiate their roles and responsibilities; responsibility for the content of the story is shared even though student Y usually has the final say.

Later on in this work session, student Y takes on the role of in-process

editor.

Example #5: [KW's classroom, April 26, 1984. Students were assigned
to write a newspaper article using the Computer Chronicles
Prompter]

Turn Ss Action

1. X: Garrison... [X is doing key entry]
2. Y: It's librarian, not liabrarian.
3. X: Okay.
4. Y: Oh no.
5. X: (I messed up) How do you spell librarian?
6. Y: I'll spell it. [Leans toward the keyboard]
7. X: No, no, I'll type it, you just tell me.
8. Y: L-i-b-r...
9. X: A-i-n.
10. Y: No, it's not.
11. X: It's i-a-n.
12. Y: No, it's r-a-r,
13. X: R-a-r [X enters letters as she says them]
14. Y: I-a-n.
15. X: I-a-n.
16. Y: That's better.
17. Y: Okay.

[KW #19 April 26, 1984]

Summary. A diversity in the division of labor is a second consequence

of placing two students together during work sessions at the computer. Students divided up the task presented to them in a variety of ways, parallel and sequential processing being the prototypical procedures.

Influences on the Division of Labor

The variety of ways in which students divided the task put before them by the teacher was not randomly distributed. The two main procedures, sequential and parallel, appeared at specific times of the year. Sequential turn taking was the prevalent procedure in the Fall of the year. This was the time when students were first exposed to working with a microcomputer and teachers used "program control" software. Later in the year, when students had learned more about computer operations and had been exposed to "user control" software, this method of dividing up the task was replaced by parallel forms. A combination of social precedent, the structure of the machine and the design of the software seems to account for this shift in procedures for dividing the task.

Social Precedents

Cooperation and turn taking are social values that are usually encouraged in the elementary school classroom. Students have been told on many previous occasions to "take turns" and "to share." Classroom lessons are organized according to turn-taking conventions (Mehan, 1979; McHoul, 1978). Therefore, when students first came to the computer center in the Fall of the year, they may have initially applied their past experience with classroom turn-taking conventions to this new situation. Once they became familiar

with machine operations and the difficulties in shifting control of the keyboard after every keystroke, they may have developed new approaches, ones that were appropriate for this new medium.

Machine Design

A microcomputer is designed for one user. It has one keyboard and one monitor. The decision to place two students at a machine designed for one influenced the organization of interaction and academic work. These machine design features contributed to the competition for turns that was so notable between the students in the Fall of the year (see examples #1 and #2 above). Faced with the problem of distributing access, they devised solutions to the dilemma which was imposed by the machine's design. At first, students jockeyed for a position in front of the machine that was more advantageous for entering text. Students rushed to the computer center to gain access to this "keyboard seat." As students gained more experience, they distributed access in more cooperative ways: the duration of turns was longer (the "story" or poem not the key press became the turn-unit) and parallel processing replaced sequential processing.

Software Design

The design features of the software also influenced the interaction that took place between the students. The structure of prompts in fixed choice software (those at the program control end of the continuum in Figure 2) forced the students to consider the possibility of taking turns every time the computer complied with one of their instructions, while the structure of

prompts in open ended software (those at the user control end of the continuum in Figure 1) seemed to facilitate parallel actions, those in which one student performed one set of actions while another student performed another set of actions simultaneously.

Summary.

A shift from sequential processing to parallel processing was evident in the three classrooms as the school year progressed. The students' initial use of sequentially organized turn-taking conventions seems to have been influenced by their previous knowledge of classroom activities and the design of the machine. The shift from sequential to parallel processing seems to have been influenced by the design of the the software that the students were assigned to use.

Conclusions

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 editing essays. The teachers started the students' learning process at the computer in a decidedly social manner: pairs of students worked together to accomplish assignments. As we stated at the beginning of this chapter, we want to know whether social learning situations are productive. Do 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. Sequential processing and parallel processing were the principle ways in which the labor was divided by the students. It was by dividing the labor that students completed the task assigned to them by the teacher. Hence, at the most basic level we can say that the presence of a microcomputer in classrooms for the purposes of instruction is not anti-social; in fact, it has the potential to serve many social functions in the classroom.

Pairs of students placed at a microcomputer for the purpose of writing using software which prompted students to pick from pre-determined choices were found to divide the task sequentially. Some students alternated access to the keyboard every time the machine provided a prompt which resulted in one student responding to a prompt and the other student managing the return key. Other students conducted more operations before turning the keyboard over to the other student. By the third story in a work session in which three to five stories were written, students had settled on the story as the unit in terms of which they would take turns. Once the students settled on the story as the turn-taking unit, 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 placed at a microcomputer for the purposes of writing using software which placed control of the task literally in the hands of the students divided the task in parallel. 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.

These exchanges point out the possibly productive role of verbal interaction in classroom learning. The students working together talked out loud to each other. These acts of verbalization lead the students to consider alternative formulations of tasks and to restructure tasks in the light of new information.

When the division of labor is examined across the whole school year, a general trend can be detected from sequential processing to parallel processing. The most accelerated point of the transition occurred when the software changed from program controlled to user controlled. For instance, in November, KW replaced "Storyland" (which is a "program controlled" program with "Computer Pals," which is a "mixed Control" program. Concomitant with this shift in software is a shift from sequential to parallel processing. Similar transitions occurred in the other two classrooms as well. Hence, 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.

It is interesting to note, furthermore, that students did not revert to sequential processing once they gained experience with parallel processing. KW introduced software during the month of February ("Expository Tool") that starts students at the forced choice end of the software continuum (see

Figure 8 above). Students continued to divide the task in parallel. This suggests that software, while important in determining division of labor patterns, is not the sole determinant. In this case, a new social precedent had been established and was maintained despite software changes.

The relationships between software design and methods of dividing the computer task are shown in Figure 9.

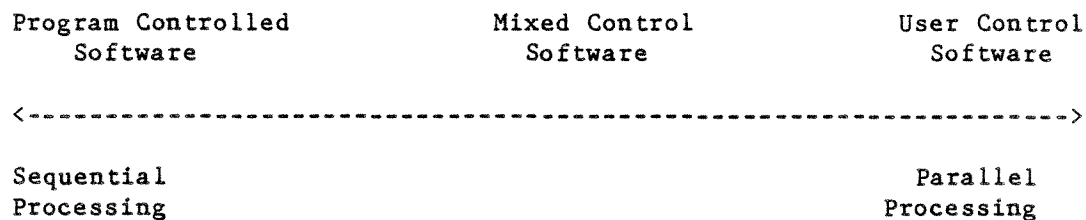


Figure 9: Software Design and the Division of Labor