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ABSTRACT

Three school systems were examined to assess issues pertinent to microcomputer innovations in the schools, and to determine whether a revolution in education was taking place because of this new technology. A case study approach was used in this exploratory analysis in order to collect information from four levels: students, administrators, technology specialists, and the community. The three sites chosen for the study were selected on the basis of the diversity of their geographic location and the type of school population served. It was discovered that school systems tend to adapt microcomputer use to their own goals, needs, and ways of operating. Although several common trends were observed among the systems studied, it was concluded that microcomputers on their own will not promote any particular outcomes, and their impact will depend largely on the educational context in which they are embedded. A paucity of research literature on the educational and developmental consequences for children using microcomputers is indicated. (MER)

Issues Related to the Implementation of Computer Technology in Schools: A Cross-Sectional Study

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Children's Electronic Laboratory Memo No. 1

ISSUES RELATED TO THE IMPLEMENTATION OF COMPUTER TECHNOLOGY IN SCHOOLS:

A CROSS-SECTIONAL STUDY

There is much excitement about the potential of microcomputers in education. There are some who argue that these powerful, engaging, personal, and relatively inexpensive machine may decentralize education by placing decisions about it squarely in the hands of students and teachers. Others claim that micros can greatly expand children's cognitive capacities. Some think they will change the nature of the social interaction in the classroom.

Schools are buying microcomputers at a rapid rate. Yet, with the exception of anecdotal reports, we don't really know how microcomputer innovations are taking place in schools. In fact, we don't even know what are the most important questions to ask about this new technology.

Within this context of both excitement about the potential for microcomputers as well as questions about their diffusion and effective use in school systems, we examined just how this technological innovation is proceeding in three very different school systems. The purpose of our study was to discover those issues and questions which would constitute a research agenda.

Ours was a careful look at three school systems which could inform us about emerging issues. Since our goals were exploratory we used case study methodology. We wanted to understand a few school systems in depth, to obtain as complete a picture as possible of each microcomputer innovation. We assumed that comparisons among sites would yield trends for future study.

If there was one general question in the back of our minds as we conducted this study it was: Is there really a revolution taking place in education as a result of this new technology? We emerged with a healthy respect for the ability of school systems to assimilate innovations to their own values and ways of doing things, as well as with the sense that there were some potentially powerful changes taking place.

In planning our research we assumed that, in order to understand a technological innovation and its impact on children and teachers in classrooms, we had to go beyond the classroom. There are at least four levels or contexts within which an educational innovation takes place--a community, a school system, a school and a classroom. Decisions which are made, events which occur, and beliefs which are held at each level may ultimately affect the nature and scope of the impact of the computer on children and teachers in classrooms.

Therefore, we collected information from all of these contexts for each community we visited. We spoke with community persons, including parents, board of education members, local computer business people, politicians, and journalists. We interviewed people at all levels of the school system--district administrators, school administrators, computer resource personnel, media specialists, teachers and students. In addition, we observed students using microcomputers in classrooms, computer resource rooms, media centers and after-school clubs. Finally, we collected recent newspaper articles related to the school system, as well as documents published by the school systems. In all, we interviewed 80 teachers, 30 students, 24 school administrators, 14 district administrators, 8 technology specialists, and 10 community persons. In addition, we conducted 51 observations of students using microcomputers.

We brought multiple perspectives and skills to our investigation. Our staff included a sociologist, educational psychologist, cognitive/developmental psychologist, curriculum specialist and educational technology specialist.

We chose our sites in order to maximize diversity--diversity of geographic location, of school populations served, of goals for implementation, and of applications. All sites had been using microcomputers at both elementary and secondary levels for up to two years. As it turned out, the school systems we chose all began time-shared instructional computing in the 60's and are still using terminals for some purposes. This report, however, will focus only on micros and their use.

Our first site is a large city in the southwest, which we call Salerno; the second, a somewhat smaller city in the midwest, called Granite; and the third, a small northeastern suburb, called Greenview. In this paper the microcomputer implementation at each site is described briefly, followed by a discussion of some of the trends, questions and issues which emerged. This is a preliminary report, based on data collected from October through December, 1981. Data analysis is still in progress, and personnel from each site have not yet reviewed their case studies.

SALERNO

Salerno presents a model of an innovation in which authority and resources are centralized. It is a carefully planned innovation, with explicit curricular goals. It takes place primarily outside the classroom, and in this sense is peripheral to ongoing classroom life.

Salerno is a major southwestern city of about 800,000 in a metropolitan area of about 1.5 million. Its public school system serves 122,000 children. Insurance, banking and technology make up a significant portion of the economy. The wealthiest residents in the metropolitan area live in suburbs with their own school sytems, leaving a city population of primarily middle and lower income residents.

Although the metropolitan area has been increasing in population, the school system itself has lost a considerable number of students (estimates range from 25,000 to 50,000). As a result of a bussing program which was instituted in response to a desegregation order, many middle class majority children were sent to private schools and many families moved to the suburbs. Thus, the city school system is largely minority, with approximately 45 percent Black, 20 percent Hispanic and 35 percent White children.

The highest current priority of the Salerno school system is raising its students' scores on state and national standardized tests. Its students have not done well nationally or by comparison with other cities in the state, although the most recent scores represent some improvement. In the last few years, therefore, the school system has placed great emphasis on basic skills. Detailed baseline objectives have been established in many curricular areas.

The microcomputer innovation began in Salerno as a way of enhancing the basic skills of students who were below grade level. A superintendent enthusiastic about innovation and technology began the development of software within the school district. The instructional design group was to produce comprehensive basic skills packages which could provide drill and practice for students whose performance was below grade level. This software development operation has represented a large commitment of funds and resources on the part of the district. Last year the instructional design group employed 24 full-time staff at a cost of almost $600,000. Of this almost $400,000 came from district funds. The rest came from Federal monies. These technology and curriculum specialists have produced a k-8 math skills package and are developing packages in reading and higher order math skills.

The k-8 math package is currently in use in 60 of the 180 schools in the district. Three hundred TRS-80 computers were purchased with Title I and state compensatory education funds for this basic skills program, and 300 more are expected in the system this year. Because of the source of funds, the use of micros is limited to those students who are below grade level.

The administrator in charge of micros is the assistant to the math coordinator in the district. She places micros in schools, is in charge of training for teachers and aides, and provides information and support to schools as needed.

Microcomputers are being used in high schools for programming and literacy, while at the lower grades the microcomputer in Salerno is seen as a curricular tool, rather than as itself an object of study. From kindergarten through 8th grade the computer is for practicing skills.

In most schools the micros are located in a resource room, and students leave their classrooms to work with them for about 50 minutes a week. The entire computational curriculum is sequenced, and students are assigned to practice a skill at a level indicated by their classroom teacher or by a Title I teacher. These resource room teachers supervise aides who help the students use the micros.

Teachers and aides were trained to use the micros during a special workshop. They learned to load and run a program, how to select practice problems for students, how to keep records, and how students were to type in their responses. They also learned the scope and sequence of the computer-based curriculum, how the different strands are organized, what the different levels are and how they relate to the classroom curriculum. Aides and teachers reported that this training was adequate, that they felt comfortable with the microcomputer, and that they felt it was a valuable instructional tool.

Since the same baseline objectives guide the development of the software and the classroom math curriculum, there is an overall relationship between work in the classroom and in the resource centers on the micros. Work on the micros, however, did not necessarily coincide temporally with related work in the classroom. A concept could be introduced in class long before it was practiced on the micro.

What are the effects of the micro math practice on students in Salerno? No one knows. The teachers felt it was too soon to tell, and the school system had not yet conducted an evaluation. Clearly the expectation is that the practice and additional time on task provided by the technology will prove effective.

We observed a range of involvement and enthusiasm as students worked with computers. Some students were interested and eager, others seemed bored or resistant. The work was done on a strictly individual basis, so there was no opportunity for social interaction. Some of the students we observed seemed challenged by what they were doing, while others seemed to need instruction in the computational procedure, rather than practice with it. If children were confused, they tended to flounder or guess randomly in order to move the program along, although sometimes a teacher or aide recognized and responded to a student's need for instruction.

When we tallied the use of micros by sex, we found more boys than girls using the micros in all grade levels. The ratios, however, were not large. In addition, we did not visit enough high schools to make a judgment about the extent of sex differences there.

To summarize, Salerno is a model for using the microcomputer as a mode for delivering curriculum. It is carefully planned, consistent with the priorities and goals of the school system, and represents a large investment of resources on the part of the school system. It could affect test performance of large numbers of children in the school system without directly making any kinds of changes in regular classrooms.

The Salerno model could dramatically change staffing patterns and instruction in the district. As indicated earlier, other large packages of software are currently under development--reading and higher order math skills. These are going beyond drill and practice and taking on tutorial functions. In the future, it is possible that large portions of the curriculum could be delivered via micro. If so, then the aides who assist children in operating the micros and the resource teachers who supervise the delivery of computerized instruction could take on greatly increased importance in the system. Teachers then would presumably become managers of instruction who focus on social skills and higher level conceptual development with their students. The effects of such a three-tiered system (master teachers, supervisors of computer instruction, aides of computer instruction) on education can only be speculated about at this point. What is clear, however, is that in such a system the creators of software will become, to a significant degree, the creators of curriculum.

GRANITE

Our second site, Granite, is a model of innovation in which some resources and authority are centralized, but in which actual use and decisions about use are decentralized. The innovation is loosely structured, without explicit policies or curricular goals.

Granite is a city of 370,000 people in the midwest. Its major industries are agri-business, technology and insurance. The city has a varied population, including Whites, Native Americans, Asian Americans and Blacks. All socioeconomic groups are represented in the city itself. The school system is about 30% minority.

The school system has lost large numbers of students due to a decline in the school age population. The system has shrunk from 70,000 to 41,000 students in the last 12 years--a decrease of greater than 40%. With that the system has had to decrease staff and tighten its belt. Like Salerno, Granite has been under a desegregation order. In Granite, however, there has been little movement to private schools as a result.

The Granite system values diversity and provides many educational options. There are fully eight different elementary educational programs from which parents may choose for their childen. While there are some agreed-upon curricular goals, the system does not specify detailed objectives. Standardized tests are used early in the year for diagnosis, rather than for accountability and evaluation at the end of the year.

There are currently 80 Apple computers in the city system--40 owned by schools, purchased out of operating funds or with grant monies, and 40 "loaners" owned by the district and loaned to schools on requests from teachers. The micros are in 23 of the districts' 100 schools and other instructional sites. The computers are managed by a computer resource teacher located in the office of the math curriculum specialist for the district. The computer resource teacher processes requests from teachers for machines, meets teachers' requests for help with the machines or with related curriculum, and conducts workshops and other forms of teacher training.

A unique feature of the Granite system is a state organization which coordinates and facilitates instructional computing at all levels of education in the state. This central computing organization provides teacher training, as well as Apples at discount prices. In addition, it makes available software which it has evaluated, and in some cases refined and developed, to all public schools at no cost. The Granite schools use this software, and supplement it with some which is locally produced and some which is purchased commercially.

At both state and city levels there is a commitment to computer literacy, broadly defined, and equity of access to computing. But neither at the state nor the city level are there centralized policies about the use of the microcomputers. The micros are seen very broadly as a resource for teachers, which teachers can use in any ways they consider appropriate.

The microcomputer innovation began in Granite in 1979. There was both grass roots and district interest in purchasing micros even before they were available as free-standing machines. The central computing organization acted as a catalyst for the purchase of micros with its decision to contract with Apple. This meant that schools and districts could buy Apples at a discount and that software would be provided for Apples. At that point the math specialist and central administrators decided to purchase the loaner Apples.

It is difficult to summarize and characterize what we saw in Granite, since uses, goals and settings were varied. Microcomputer applications include programming, drill and practice, simulations and games. Teachers' goals for the instructional use of the micros vary from giving students something that's fun to do when they've completed their work to achieving computer literacy to enhancing logical thinking. The micro provides Title I remediation for below-grade students, as well as enrichment for high achievers.

The initiative for getting micros into schools is taken largely by individual teachers and, in some cases media specialists. They make requests to the computer resource teacher or write grant proposals. Most do their own computer-related work enthusiastically. But it is unusual to find a teacher who takes an active role in broadening the innovation by involving and supporting other teachers. Some teachers have been given computer-related assignments in order to keep them in the system, and not all of these are yet sufficiently trained for that work. In general, the demand for training by teachers seems to exceed that which can be supplied by state and local resource persons.

In the elementary schools we visited micros were used primarily at the intermediate grades, 4-6. We saw them used in media centers, hallways, resource rooms and, occasionally, in classrooms. Programming has become part of the curriculum in many schools for this upper elementary group. The least extensive use of micros was in the junior high schools. There we saw micros used in an after-school programming club for 8th and 9th graders and for Title I remediation in math and language arts. In the senior high schools there is more extensive use of micros. There the use in confined almost exclusively, however, to classes in math and business.

At all levels we observed more boys than girls using the computers. At the elementary level the male/female ratio was 1.6 to 1, while at the high school level this number had increased to 3.5 to 1.

What were the effects on students of using the micros? Teachers felt that micros were making a difference to students, but few talked of learning outcomes. Teachers of programming and computer math felt that with the micro, students had a powerful problem-solving tool. Many teachers felt that motivation, interest, status among peers and feelings of efficacy were enhanced when students worked on the machines. The microcomputer has proven particularly useful for a new group of Asian immigrants who are learning to speak English. They practice math on the micros, an activity which doesn't require much English. This has helped them to feel good about themselves as learners in a new and foreign environment. Teachers noticed and mentioned sex differences in the use of the micros. Some teachers felt that girls approached it more cautiously at first, but ultimately could become as involved as boys.

With programming offered as early as third grade, student experts have begun to spring up. Typically male, these students are sometimes used to help other students, and occasionally do programming for teachers. Some of the high school experts have gotten jobs as programmers and technicians in local computer stores.

Teachers want more software and more training. Some emphasized that their security in the school system had been enhanced by their computer-related skills.

Administrators at the district level all agree that the system will support and expand technological innovation. One raised some important questions about the future. Is the micro an instructional tool or complementary to the curriculum? What really is its educational potential, and how can we assure that its use is multicultural, interdisciplinary and creative? If commercial people develop the software, will it be junk? Even with all of these doubts and questions, this administrator will spend any surplus monies this year on micros because of the demand and interest.

Most of the principals we spoke with were relatively uninvolved with the microcomputer activities. There are plans at the district level, however, to involve principals and to encourage them to use computers for administrative record-keeping and computer-managed instruction.

With so many different things happening and on so few machines, it is difficult to detect patterns in Granite. Yet there are two that deserve mention.

First, most of Granite's micros are not in classrooms at the elementary level. They are in resource rooms, media centers and hallways. Such locations may represent a desire for equitable access to the computer, but we sense it is more likely to represent the genuine challenge of integrating computers into classrooms. At the secondary level the computer is in classrooms, primarily in the math and business departments.

Second, it is clear that the computer expertise which students are developing is putting pressure on the system which it can't always meet. While teachers themselves don't seem to be spreading the innovation, students' needs for additional courses and better trained teachers may have an impact.

To summarize, Granite is a model of a loosely structured innovation. Micros get into schools by different routes, with different funding sources, and are used for different purposes. Most of the energy for the Granite innovation has come from the grass roots, with some key resources provided centrally. There are no specific plans or policies governing the use of the micros.

GREENVIEW

Our third site, Greenview, is a model of an innovation with most authority and initiative at the grass roots level, with central administrators providing support and encouragement. There are no comprehensive policies or plans for the microcomputers. Decisions about use are decentralized. Greenview is unique in the emergence of a new role, the teacher buff.

Greenview is a northeastern suburban community of about 25,000. The community consists largely of business and professonal persons who work in a nearby city. The socioeconomic level of the community is high. Students do well on national norms, and almost 80% of the high school graduates go on to postsecondary education. In general, the school system is eager to keep abreast of educational innovations, and to maintain its emphasis on preparation for college and beyond.

Over the last ten years Greenview has had declining enrollments of about 15% overall. It now serves about 5,500 students. Declining enrollments and budgetary constraints have limited new hiring in recent years.

The school system has been moving toward greater centralization with respect to issues of curriculum accountability, and evaluation. It hopes to have in place soon a detailed set of objectives for each curricular area, criterion referenced tests keyed to these objectives, and a statistical system for the district's administrative computer which will make it possible to trace students' progress through the educational system.

There are 37 micros--34 Pets and 3 Apples--in the district, used primarily in the 7 elementary schools and 2 junior high schools. Four of the Pets are loaners, while the other 33 micros belong to the schools which house them. They are used for remediation, drill and practice, reinforcement, literacy and programming. They are used for the full range of students, including the learning disabled.

Most of the initiative for getting microcomputers into schools has come from parents and teachers. The district supports a high school teacher who serves as computer coordinator. She is located at the high school and, in addition to her district-wide responsibilities, teaches two computer courses and runs the high school computer clubs.

The most significant form of support from the district is through inservice courses. Computer-related courses, taught by local teachers, are offered frequently. In addition, the school system makes a contribution towards tuition for teachers who get computer-related training elsewhere.

Microcomputers first came into Greenview schools at the initiative of the computer coordinator, with administrative approval. In the fall of 1979 one Pet was placed in each of the elementary schools. These were purchased out of district funds. One teacher from each elementary school was trained the summer before the Pets arrived. Since then, these schools have bought additional micros with funds obtained through grants, through parent-teacher organizations, and from school operating budgets. Because all of the additional micros have depended on teacher and parent initiative, there are now unequal numbers of micros in the elementary schools. The role of principals has ranged from supportive to negative, with many neutral. In at least one case a principal has changed his public posture from negative to positive in the face of parent enthusiasm.

Software in Greenview has been acquired in various ways, primarily from inexpensive sources, such as Cursor magazine and other public school systems. There is some commercially produced software, as well as some programs which were produced in the district by teachers and students. High school students are responsible for updating the set of tapes which has been collected and duplicated for each Pet. A catalogue of Greenview tapes describes each program, gives grade levels, and rates software according to Bloom's taxonomy. The software is largely drill in math and language arts, sometimes in a game format.

At the elementary level micros are used more in the upper than in the lower grades. They circulate to classrooms on a sign-up basis. There is generally one teacher who manages the micros, usually a teacher buff. The buffs are very knowledgeable about micros, and have given a great deal of personal time to becoming so. Beyond this, they are enthusiastic about the micros, and are eager to involve other teachers in this innovation. Without compensation in time or money, they teach, give support to and spread the word among other teachers. We found both male and female buffs, some with and some without previous computer experience. One teacher told us that it was impossible to predict who would become a buff, who would find these machines captivating. In most of the elementary schools there was at least one other micro buff--in some cases a teacher, in others a parent.

Microcomputers are clearly in elementary classrooms in Greenview, in contrast to other sites. Elementary teachers have varied goals for using the micros. Some want children to have fun while learning, others want students to be comfortable with computers. Some focus on children's skill development, others on the teaching of programming and problem-solving.

Even though the micros are physically present, there seems to be a lack of integration with the curriculum. Children were often observed doing drill and practice in areas which did not coincide with current classroom instruction. In one classroom we observed children working on mapping skills as seat work and using related skills in a computer game. Yet neither teacher nor students seemed aware of the connection.

The teacher buffs and special education teachers have carefully articulated views of how to integrate work on the computer with other modes of learning in the classroom. For many other teachers, though, such integration was not a stated goal. Many of them are at a much more tentative stage with respect to micros. They need first to master the machine before they can think about ways of using it productively.

At the secondary level micros are used primarily in the junior highs. A computer literacy course has just been initiated for all seventh graders. An attempt is being made to involve teachers from non-math areas in this course. Elective courses in programming and computer math are available to eighth and ninth graders, and there are after-school clubs. Micros are used for other subject areas, including English, vocational education and earth sciences.

In the junior highs the micros stay in one room (also the classroom of the math and computer teacher) and students go to those classrooms. In order for teachers in other subject areas to use the micros, class locations must be switched. This process is very cumbersome, and requires planning far in advance of actual use. Therefore, it is difficult for the micros to be used broadly.

At the high school the two micros are used for classroom demonstrations and for programming by high school students who write software for the elementary and junior high teachers who request it.

Teachers in Greenview are in general enthusiastic about the micros. Some reported that the micros had an effect on their role in classrooms, putting the children more in control of their own learning and teachers more in the role of resource persons who answered questions and shared children's discoveries. Some teachers felt that they learned new things about their students by observing them use the micros. Teacher buffs have a new relationship with their peers. They are now teachers of teachers.

Teachers in Greenview, though, complain that there's not enough time to learn how to use the micros, to preview programs and plan for their intelligent use in classrooms. They feel there is not enough variety of software and that what there is is not conceptually challenging enough.

How do micros make a difference for Greenview students? Students themselves are clearly enthusiastic, and have initiated lunchtime and after-school computer activities. Teachers in

Greenview are, on the whole, reluctant to talk about cognitive or learning outcomes for students. They feel it is too soon to tell. However, many talk about effects relating to social interaction and self esteem. Students often work together on micros in Greenview, and teachers feel that there have been gains in social skills as a result. Some also report gains in self esteem on the part of those students who learn how to use the micros and can then help others.

Student experts have come to play an important role in Greenview. Although schools have always had students who were outstanding in some areas, these experts are different in two respects. First, they are taking on a collegial role with respect to teachers. They teach, help, and work alongside teachers, as well as with other students. Teachers are positive about this collegial relationship with their students, and don't seem to find it threatening.

Second, these experts are putting pressure on the system, asking it to meet their needs for more knowledge and training. For example, a seventh grade computer club is now learning the programming skills normally taught to eighth graders. What they will do next year concerns teachers and administrators.

Students we observed were interested and enthusiastic in what they were doing. In one junior high programming class, students didn't notice when the bell rang. The teacher claims this is a frequent problem. In Greenview there was equivalent use of micros by males and females in elementary grades. But starting in 7th grade, males predominated by a ratio of 2.5 to 1.

In Greenview, the schools are beginning to see students who have micros at home. Although there was no report of current impact, the schools are beginning to anticipate a home-school connection around the technology. They are considering selling the tapes which are used in school to parents.

District administrators are committed to computer literacy as an immediate goal, but have questions about the future. They are concerned about the lack of coherence and policy. A task force of teachers and administrators has been formed to begin charting policies and goals, and to design a k-12 computer curriculum. From the administrative perspective, an innovation which has gone its own way, with individual teachers doing what they choose, must now be made more rational and better articulated with the goals and curriculum of the system. The Greenview innovation, then, is bound to become more centralized soon. It will be important to discover what consequences follow from this move towards greater centralization.

CONCLUSIONS, TRENDS, AND QUESTIONS

Having briefly summarized our data, what conclusions can we draw? We have seen three different innovations which reflect the school systems of which they are a part. School systems assimilate microcomputers to their own goals, needs, and ways of operating. Clearly Salerno would not have a Granite-style innovation, nor the other way around.

On the other hand, each system is now experiencing or is likely to experience changes resulting from this innovation--new staffing patterns, new roles for teachers and students, new sources of curriculum. If there is a microcomputer revolution going on, it may take different forms in different contexts.

There are five trends we observed which we think raise qustions of critical import. These are:

--Differential access to the microcomputers
--The emergence of new roles in response to the microcomputers
--The lack of integration of microcomputers into elementary classrooms and curriculum
--The inadequate quantity and quality of software
--The lack of knowledge about the effects and outcomes of microcomputers in education

Differential Access to Microcomputers

In all of our sites we saw differential access to computers. In Salerno the differential access is deliberate, since the micro is being used to improve the performance of students who are below grade level. We wonder, though, what some of the long-term outcomes might be of limiting micro use to students who need remediation. Will the micro in grades kindergarten through eight be seen as a machine only for children who aren't doing well? One middle school teacher in Salerno told us that he felt there was a stigma attached to using the micros, and refused to have any in his classroom as a result. The students whom we observed in programming classes at the high school were all "good in math". One can easily imagine a world in which all students have access to micros, but in which levels of achievement determine what students are permitted to do with the micro. The educational assumptions behind such a division of applications, as well as the likely educational outcomes, need very carefully to be examined.

The other two sites we visited specifically valued equity of access, with very few machines being restricted to specific groups of students. However, since both sites have depended largely on local initiative, there is an unequal distribution of micros among schools. This gives some students greater access to computers than others, merely because of what school they go to. We do not think there were systematic differences between the have and have not schools with respect to student populations served. But clearly this needs to be looked at. A "local initiative" model of innovation could unintentionally result in considerable differential access.

In all of our sites we observed differential use according to sex, particularly at the secondary level. This is not an issue of access per se, since girls are not systematically excluded from using computers. At the elementary level, each sex could and did use the micro more or less equally. But, starting in seventh grade, when the micros moved out of classrooms and hallways into math and business departments, there was an overwhelmingly male representation among students who used the micros. [Although this was not a systematic survey, the consistency of our findings and the size of the differences suggest that this trend is replicable.]

It is, of course, too early to tell whether those girls who have learned to use micros in elementary school will follow them to the math department in junior and senior high. If they do, then the microcomputer innovation may be responsible for some profound changes in the sex-differentiated nature of our secondary school curriculum. If not, then the microcomputer may well become a part of the intimate connection between males and math which already exists in our schools. It is important to look carefully at this aspect of microcomputer use.

Emergence of New Roles in Response to Microcomputers

One role which has emerged is that of teacher buff. Teacher buffs, as indicated above, are not only interested in and knowledgeable about the microcomputers, but play a central role in spreading the innovation by teaching and encouraging other teachers. They give a great deal of personal time to this work, with little or no compensation. There are a number of questions about the teacher buffs which could constitute the bases of research.

First, it is important to know whether buffs emerge in only some kinds of settings. We saw them in Greenview, and not in other sites. We wonder whether there are unique features of the Greenview innovation which make it possible or even necessary for buffs to emerge. Or, alternatively, is the teacher buff a role which emerges at a certain stage of any innovation?

In terms of the future of teacher buffs, we wonder how long they will continue at the present pace before they burn out, leave the system for more lucrative positions in industry, or their roles become officially recognized and institutionalized.

Finally, it is important to determine whether the teacher buffs are necessary for an effective innovation. Does an innovation effectively take hold only when there is a certan amount of missionary zeal among those at the grass roots, or can an innovation take hold just as effectively when it is centrally planned and resources are widely distributed (as in Salerno)? It is interesting that the site in which microcomputers were in elementary classrooms is also where there were buffs. Are buffs, with their personal dedication and involvement, necessary for getting microcomputers into classrooms?

A second role which has emerged is that of the student expert. These experts are new both because of their instructional and collegial role vis a vis teachers and students, and because they are asking for something from the school system. Their need for more courses and better trained teachers poses problems which schools must solve.

We wonder whether these special roles will continue or whether it is simply a question of teachers catching up to the students. Once there are enough highly skilled teachers will student experts become "just students" again? Or will the collegial type of relationship which has been developed continue? We would like to know how schools are responding to the pressure from the student experts, and whether and how schools make use of the wealth of student expertise.

Lack of Integration into Elementary Classrooms and Curriculum

In Salerno the computers are not in elementary classrooms by design, but the work on the computer is integrated with the classroom curriculumm by way of shared objectives. We wonder whether this works educationally. Is it possible for children to relate what they do on the microcomputers to what they do in the classrooms when the related activities occur at different times, in different places and with different teachers?

In Granite microcomputers were also not in classrooms, although not by design, while in Greenview they were in classrooms, but were not well integrated with the curriculum.

We would like to know whether bringing the microcomputer into the classroom is the first step in integrating it with the classroom curriculum. Is it a necessary step? What kind of support and knowledge do teachers need in order to integrate classroom work with microcomputer activities? Will the teacher buff turn out to be an essential resource for making this happen?

Finally, we need to think about not merely whether the microcomputer can be integrated with the ongoing curriculum but about whether it will have an impact on the curriculum. In all of our sites it is. In Greenview and Granite, it is having an impact because new courses are being created to teach students how to use and program the microcomputer. In Salerno it is because the software design group is essentially writing curriculum for the district. This group uses as guidelines the baseline objectives established by the district, along with state-adopted textbooks. Nevertheless, translating an objective into software is no trivial matter.

During our visit to Salerno we watched developers taking a stated objective (e.g. students must know the difference between fact and opinion) and writing software to teach it. They first had to determine for themselves what fact and opinion were, and then translate their ideas into an instructional program. At all of these steps they were making important instructional and curricular decisions, decisions which would eventually affect large numbers of children in the district.

Inadequate Quantity and Quality of Software

Teachers in Granite and Greenview complained that there was not enough software in the non-math areas. We would like to know what is enough. What kind of a menu do teachers need? What makes some software useful and other software not? Even with the dearth of software, not all of what is available is used.

One contribution to usefulness may be whether teachers have any input to its development. Software, unlike textbooks, is unique in the local possibilities for its development and modification. In one Granite suburb we visited there is an experimental program in which teachers request software from a small development group which produces it, then field tests it with teachers and students, then modifies it, and then makes it available in the schools. This experiment has generated a great deal of local enthusiasm. It would be interesting to compare software use in this district with that in a comparable district where there is no teacher input. Modification of software is another form of teacher input, and again, it should be looked at in relation to teacher use and adoption.

Teachers want better quality software. But neither teachers nor developers seem to know, or be able to state explicitly, what makes good software. There are undoubtedly implicit standards which it would be important to probe.

More generally, what is needed is a theory of software--models for the ways in which ideas can be implemented in the software medium, along with research about how different forms of implementaton meet different educational goals and purposes. Such theory would require the synthesis of knowledge about instruction, learning, development, perception and media.

Lack of Knowledge of Effects and Outcomes

No one really knows about the educational or developmental consequences for children of using microcomputers. What teachers tell us about primarily are social outcomes related to social interaction, status and self-esteem. That many teachers made such comments clearly targets this as a rich area for study. On the other hand, that no one knew what children were learning by interacting with the microcomputers clearly targets this is a critical area for study. It's not that teachers haven't read an abundant research literature, but rather that there is almost no literature to read.

The microcomputer innovation is being fueled by a great deal of enthusiasm, with the conviction that the microcomputer is a good thing. Yet no one knows for sure if it is, how it is, or, really, what it's good for, in terms of educational outcomes. We need to begin acquiring such knowledge very quickly, in order to help guide an innovation which is bound to grow even in the absence of guidance.

What is clear from our study, however, is that microcomputers on their own will not promote any particular outcomes. Their impact will depend, not only on hardware and software, but, to a large extent, on the educational context within which they are embedded.