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ABSTRACT

If computers were used ideally in education, each student would have enough computer time, each computer enough student time, and computer-based activities would be chosen well. The move towards using microcomputers in the schools has less to do with any clear and demonstrable instructional advantage of using them, and more to do with general societal-wide interest in applicability of computers. A national survey on students' use of microcomputers in schools found that, although schools have made major investments in microcomputers, very few students get a substantial exposure and benefit from using computers, and the typical computer-using student gets little more than a cursory experience. Given the way schools must operate to provide instruction to hundreds of students, simply grafting microcomputers onto the school (and even providing the best software and best curriculum available), will not result in extensive or effective use. The organizational problems of using a relatively small number of computers in a school setting require centralized placement, supervision of younger students, knowledgeable and enthusiastic teachers, cooperative planning among teachers with divergent interests and goals, and, in elementary schools, strong involvement of the school principal. (LMM)

The Social Context of Using Computers in Schools: It's Not Just a Matter of Good Software

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In our fondest images of children and adolescents using computers in school, everyone is busy doing productive work, and the computers are nearly always in use. Children are not made to do an hour of dull and possibly irrelevant seatwork in order to get a ten-minute turn on one of the two or three computers in their classroom (which turn they share with a "partner"). Nor are computers sitting idle at the back of a classroom, because the teacher has organized computer-based activities for only a small part of what must be "covered" during the year. Neither are there idle computers in the library or in a special computer laboratory room where an adult is available for only one period each day to supervise students using computers.

We also prefer not to think of schools having made a major financial investment in computers for use by the brightest and most advanced students while they fail to provide resources required to overcome the more severe problems of alienated or failing students. Nor do most of us really want schools, in the interests of "equity" or in order to placate frightened parents, to provide all students, from age 6 on up, with a three week unit on "computer literacy" every year--thus requiring that the few hours of weekly computer access be apportioned among hundreds of students. This is especially so because career opportunities will still depend on demonstrating abilities to write well, to work with people, and to handle real-world, quantitative problems much more than they will on having been exposed, for a few weeks as a child, to a rather outmoded and difficult-to-use

microcomputer. And finally, in our imaginings, the time that students do spend at the microcomputer is time productively spent, in part because they have all mastered the skill of typing before they began trying to use the microcomputer to accomplish tasks. The typing, or keyboarding, skill enables them to communicate their ideas in a computer environment, just as handwriting enables written communication to proceed, and just as speech is a prerequisite to oral communication.

In our ideal world, it is not only that the "software" works, but that the whole social and instructional system works. It is not only that a few dozen students are kept occupied using a handful of computers for a half-hour each week, but that the students' time and the computers' time are both efficiently organized to provide educational benefits appropriate for each student and which cannot be accomplished by other means at a lower cost.

In the United States, between mid-1981 and the fall of 1983, the percentage of elementary schools with one or more microcomputers jumped from 10% to over 60%. During that same period, the percentage of secondary schools with five or more microcomputers grew from 10% to well over 50%. The total amount spent by schools on computers and related "software" and "hardware" in 1983 may have been as much as one-third the amount they spent on books for instruction in all subject-matters and all grade levels combined.

Why this movement has taken hold so rapidly and so broadly has little to do with any clear and demonstrable instructional advantage of using computers in a school setting. It has more to do with the general societal-wide interest in the applicability of computers that has blossomed across a wide range of institutional contexts from small businesses and voluntary associations to religious study and family life.

For schools in particular, several motives seem apparent: Parents worry that their children will be unemployable unless they know how to use computers in ways their future employers might like. Since computers are not yet within the easy reach of most families, and since many parents feel incapable of guiding their children's learning through a medium with which they have had little experience, schools are widely seen as the most appropriate setting in which to confront this problem.

Many teachers and school administrators fear that they, too, need to know something about how to use computers. A number who have tried programming or using computer programs on their own find it intellectually stimulating. Like adventurous computerists in other professional domains, they become proselytizers for their use by others in their workplace. This happens first and most often in high schools and among mathematics teachers, for whom computers, as objects to be programmed, are most easily integrated into other instructional responsibilities.

By virtue of their nature--interactive, colorful, manipulable, and logical--the new breed of personal microcomputers appears to have attractive features for providing instruction and intellectual challenge for adults, adolescents, and children. Many people, having access to computers for the first time and recognizing a plausible concordance of computers and education, write and market programs with manifest instructional content. They do this for a variety of reasons, not the least of which is that they enjoy doing it. As profitability becomes apparent, development projects become more highly capitalized, and a high proportion of costs become allocated to product design, marketing, and advertising. More effort is directed at the lower grades where there is less curriculum differentiation, where the instructional content is less complex, and where the unique attributes of the computer--dynamic and interactive color graphics--make it relatively more attractive than alternative instructional media.

Schools and school systems, with varying degrees and emphases, either accept the plausibility of the instructional value of computers and invest in a major way, or, acting with more reservation, find that, with some sacrifice, they can afford to purchase one or two microcomputers, in order to explore for themselves what the excitement is all about. In just a few years, an entire industry has grown up, much of it focused on selling schools on the value of their products for improving the content of school life through the use of computers.

With such a sudden emergence of "computers" in the instructional repertoire of schools, it is not surprising that an intellectual and empirical rationale for their educational value has barely begun to develop. At the same time that schools invest much energy and resources in developing computer-related curricula and in purchasing computer-based instructional materials, scholars and researchers are still addressing critical questions whose answers, by all rights, should precede, not follow, the actions of practitioners--questions such as the following:

* "Compared to the clearly important goals of developing broad verbal and mathematical fluency among students including writing and problem-solving skills, and compared to the importance of teaching other culturally valued knowledge such as that from scientific, historical, and literary domains, how necessary is it that schools spend valuable instructional time teaching students about computers, and specifically, about how to 'program' them in general-purpose computer programming languages like 'BASIC' or 'Pascal'?"

* "Are there other non-traditional skills, such as "information storage and retrieval techniques" or "testing quantitative models," that are appropriate in today's secondary school curriculum because, in the near future, many adults will want or need to use similar

computer capabilities in their work or in family or recreational activities?"

* "For which types of students and for what portion of the traditional curriculum, if any, are computers a cost-effective way of improving student skills and competencies?" That is, with the best available (or even the 'best possible') educational computer programs, are there some students (e.g., 'slow-learners' or 'gifted and talented') for whom some skills or competencies (e.g., 'decoding skills,' 'scientific principles,' or 'basic concepts of arithmetic') are more cost-effectively learned through using computers instead of alternative media or methods?

* "Even if theoretically better for the instruction of individual students, can most schools appropriately allocate and use the relatively few microcomputers they own when they are accountable to hundreds of variably-prepared and diversely-talented students grouped in classrooms where each teacher must simultaneously and independently teach 25 or more children?"

Although schools in the U.S. and elsewhere have made major investments in microcomputers during the last two years, the typical American school still has more than one hundred students enrolled for each computer owned. The inevitable result is

either that very few students get a substantial exposure and benefit from using computers or that the typical computer-using student gets little more than a cursory exposure.

In elementary schools, this description is particularly apt. During the 1982-83 school year, I conducted a national survey in the United States that examined how students actually use the microcomputers in their schools. The survey found that, during an average week, only about one-eighth of the students in elementary schools that owned microcomputers had an opportunity to use one. More significantly, the students who did use a microcomputer spent on the average only 20 minutes at the computer during the week, some of this in a paired or group situation. Only one out of 50 elementary school students who used a microcomputer for practicing math or language skills during the week spent more than one hour at the task--that is, about 15 minutes each day. At many schools, different students were given a turn at the computer in different weeks. Elementary schools that had a few more microcomputers than the typical school gave exposure to more students, but each computer-using student at those schools got no more time per week at the computer than did computer-using students at elementary schools with only one or two computers.

One result of the rather limited exposure which each elementary student received is that they probably learned relatively little math or language arts as a result of using the computer; they probably learned something about what it is like

to use a "home" microcomputer. How valuable that learning is--and how necessary it is that schools provide it--is a matter of debate.

Schools with fewer than 15 or 30 computers not only suffer from having to divide computer time among hundreds of eager students. They also must make important organizational adjustments in the allocation of adult supervisors to student classrooms. It is extremely expensive for schools to allocate the presence of a single adult to a classroom with less than 20 or so students. Yet most schools with microcomputers have enough computers for simultaneous use by less than one-fourth of the students in a single classroom. This means that schools must assign to a single teacher the supervisory and instructional responsibility for only a small number of students at once--perhaps 10 students at a time sharing the use of five computers; or that regular classroom teachers, responsible for 30 students, must organize additional appropriate tasks for the 25 or so students who otherwise would spend 5/6 of their time waiting for their turn at the computer.

Most schools are in session for about six hours each day. In addition, many schools allow access by certain students prior to scheduled classes and after school. It would be possible for computers to be in use nearly eight hours each day. Some schools in the national survey, in fact, did report nearly continuous use of their computers. About one-fifth of secondary schools, for example, said their computers were used by students for more than

5 hours per day each. But typically, schools reported using their microcomputers for 2 to 3 hours per day.

Five hours per day would indicate an extremely well organized school. It would mean that, if, for example, the computers were in a regular classroom--where they are in about half of the computer-using schools--the classroom teacher would have worked out procedures whereby most of the class would be involved in whole-class instruction, group-work, or seatwork, while a few students went back to take their turn at the computer. And throughout the day, students would move, with little confusion or interruption of others' work, between computer and seatwork, or between computer and recitation or class discussion.

Having some students use computers while the rest of the class is doing seatwork, an arrangement more common than any other, may be the easiest way to use computers, but it may have a net negative impact on instructional efficiency. The time spent at the computer is likely to be time well spent. Repeated observation suggests greater engagement with computer-based learning activities, and most research finds measurable improvement in learning efficiency--at least for well-defined learning tasks. On the other hand, some research has shown that seatwork time involves more distraction and less on-task time than direct instruction, particularly in elementary schools. Thus, if teachers alter their instructional delivery methods and assign more seatwork than they otherwise would in order to enable

greater use of computers, the net result may be that overall time-on-task, engagement, and learning will be negligibly or negatively affected.

Much of the time that computers are used in classrooms is spent with students working in pairs and groups at the computer and with some students watching other students work at the computer. It is possible that these social arrangements are useful; particularly if the computer programs have been designed with this group involvement in mind. Unfortunately, very few instructional programs are constructed for group use. It is likely that the primary purpose that teachers group students for computer use is to give students a sense that they have access to the computer for more than the one-thirtieth of the time that they might if the classroom had but one computer and students used it one at a time.

In our survey, for example, four-fifths of the responding elementary school teachers with microcomputers in their own classroom had only one or two computers. These were in use, typically, for about half of the time the teacher was doing math instruction and about 15% of the time that the teacher was doing English or language instruction.

Secondary school students who use computers appear to get much more time with their school's equipment. Secondary schools in the U.S. use their microcomputers somewhat more than elementary schools do--typically about two hours per week more. However, they also have more computers per capita, and they

provide use to a smaller proportion of their students than do elementary schools. The result is that secondary school micro users get at least twice as much time per week as do elementary school students who use their school's equipment. Where the typical elementary school student using a computer during a week gets about 20 minutes of keyboard access, the typical secondary school student gets about 45 minutes per week.

The difference is particularly great for students who use computers for programming activities. In public high schools, the typical programming student gets 90 minutes of computer time during the week; while the budding elementary school programmer uses the computer for 19 minutes. Even among students who use computers for computer-assisted-instruction, secondary school students get slightly longer access during a week than do elementary school student users. Part of the reason seems to be that more secondary school use is in computer laboratories than in classrooms.

In a laboratory environment, continuous use of computers requires either that the students be mature and capable enough to work without adult supervision or that a staff member be allocated full-time to the task of monitoring student computer use. If a school had twenty or thirty computers, such a staff allocation might be feasible in most schools. However, as of the survey date, only 3% of elementary schools and 8% of secondary schools had as many as eight microcomputers, let alone twenty or thirty. Even with the number of computers in schools doubling

every year, the ability of students to work on computer projects without adult supervision will continue to be an important condition of determining how computers are used in schools and how much they can be used.

In spite of the supervision problem, though, the schools in the survey that did report nearly continuous use of micros each day were disproportionately schools that put their microcomputers into computer laboratories, even when they had as few as three of them. If we hold constant other factors that also affect how much the school microcomputers are used--including the number of microcomputers at the school--the existence of a computer laboratory by itself means at least several more hours of use per micro per week.

Besides location of the microcomputer equipment, another important set of predictors of how schools use their microcomputers is who led the effort to acquire them and decide how they would be used--that is, the role of teachers, principals, and other administrators. In analyzing my survey data, I found a consistent and strong impact of the "single teacher implementation"--that is, schools where an individual teacher, interested in the idea of using computers, figured out how to acquire one or several for the school, and organized its use for his or her own classes or for the school at large.

I had hypothesized that microcomputer use would be most effective when one teacher took the initiative, unrestrained by bureaucratic meddling or compromise among traditionalist faculty

members. Instead, I found that, even controlling on the number of students and the number of computers at the school, the socio-economic environment, and the extent of computer experience, elementary schools where a single teacher was responsible for organizing microcomputer use reported less use of their micros--that is use during fewer hours of the week, by fewer students, and with each getting less computer time. Overall, these schools--and often it was the computer initiator himself who was the survey respondent--reported that the computers had much less of an impact on academic learning and less of a social impact on how instruction occurred than did other schools. At the secondary level, these differences were much smaller, but generally in a similar direction.

Indeed, for elementary schools, the best results seem to have occurred when groups of teachers and the school principal jointly planned the computer acquisition and organized how the few computers would be used. The role of the principal and other administrators was particularly important for assuring that "average" and "below-average" students got their share of computer access and for assuring that computer use was organized effectively so that there was a broad perception that learning actually occurred as a result of computer use.

This is not to say that teachers were not important. As a matter of fact, one of the strongest predictors of most of the outcomes which I examined was the presence on the school faculty of teachers who spent time writing computer programs and using

the computer in other ways, or who considered themselves to be computer hobbyists. Schools with computer-enthusiastic teachers produced involvement in computer activities by more teachers, computer use by more students, use for more applications, more time-in-use at elementary schools, and more equity of use in secondary schools--all net of other background variables.

But teachers with computer knowledge and enthusiasm without the involvement of other teachers or the principal could not by themselves create the conditions under which a small number of microcomputers could be effectively used in a school context--particularly in elementary schools. Instead, elementary schools with a single dominant computer-interested teacher tended to limit use only to the faster-learning students and primarily to teach these rather special children to program microcomputers in the BASIC language. Without the structural involvement of administrators, librarians, or other teachers, a single teacher could provide an independent activity for a few easy-to-supervise fast-learning students, but could not make a substantial difference in how many students experienced their schooling.

On the other hand, schools lucky enough to have several computer-interested faculty members willing to work together and an involved principal able to organize supervision, allocate use, and provide resources may be in a much better position to accomplish something useful with their relatively limited equipment.

The important point is this: Given the way schools must operate to provide instruction to hundreds of students, simply grafting microcomputers onto the school--even providing the best software and best curriculum available--will not result in extensive or effective use. The organizational problems of using a relatively small number of computers in a school setting require centralized placement, supervision of younger students, knowledgeable and enthusiastic teachers, cooperative planning among teachers with divergent interests and goals, and, in elementary schools, strong involvement by the school principal.

It is surprising to me that most of the attention devoted to improving the applicability of computers to school instruction is focused on improving the quality of the computer programs--the one-on-one computer-student interaction. Clearly there are differences between the worst, the best available, and the best possible programs for a given subject and a given grade level--just as there are differences between the worst and the best textbooks. Nevertheless, the best computer programs are worthless in a school context without a means of using them with the current ratio of students to computers, without a plan for mutually reinforcing learning at the computer terminal and learning away from the computer, and without an appropriate model of what instruction should be provided to which students at what age.

If schools had textbooks in the ratio to students that schools typically now have computers--one book for every one

hundred students--one would hope that schools would be thinking about how best to use such a small amount of materials while providing daily, continuous supervision and instruction to classes of 25 to 35 students each, just as they would be trying to select the texts with the best possible content and presentation. We often forget that the computer, although similar in many attributes to instructional media like television, overhead projectors, and film-strips, shares with the textbook--and not with these others--the characteristic of generally being used by an individual student rather than a classroom of students at any one time.

However computer use is organized, it must be done in the context of the school's major organizational constraint--providing presumably appropriate activities for hundreds of heterogeneously talented students of varying ages and maturity grouped for purposes of instruction and supervision into chunks of 25 to 35 individuals led by a single adult in an enclosed physical space.

Computers could assist children's learning in many ways. But only if each student gets enough computer-time, and each computer gets enough student-time, and the computer-based activities are chosen well, will computers make a qualitative difference in the amount or kind of learning that students accomplish during the course of a school year.