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ABSTRACT

This paper discusses several interrelated issues that concern four Canadian elementary school teachers who expect to be asked to introduce computer literacy into existing curriculums in the near future. Topics addressed include: (1) how teachers fit computer instruction into their existing practices; (2) status of the subject in their school; (3) principal's attitude toward the educational value of computer awareness activities; (4) ways in which teachers actually use computers (computer awareness, programming, etc.); (5) methods of computer education, including the "teach yourself" method; (6) student reactions to computer instruction, including specific software packages; (7) teacher opinion about the demands of teaching a separate computer subject; and (8) teacher needs, e.g., more time to prepare, adequate hardware, support personnel. Problems of integrating computer experiences into the curriculum are addressed and five questions are presented which illustrate the difficulty of establishing computer literacy courses in the elementary school. Finally, the topics of teacher education and preparedness are discussed, and an agenda for teacher education is proposed. It is suggested that teacher education and curriculum are closely tied, and that how the computer is conceptualized as a subject in the elementary school will have an important bearing on the agenda that is set for teacher education. A list of references is attached. (JB)

# Computers in Canadian Elementary Schools: Curriculum Questions from Classroom Practice.*

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## Introduction

In this paper we are concerned about a number of inter-related issues. First, how do teachers fit teaching the computer as a subject into their existing practices? Second, how do they explain why they are doing things as they are? Third, what experiences with computers have been significant in forming their approach to using computers? As we deal with these questions we hope to begin to fit the pieces together in order to make sense of these practices in terms of the teachers' purposes (Olson, 1980;1981;1982).

In this paper we shall consider the nature of computers as a subject as these teachers construed it, how they taught the subject and why they felt it important to teach it. What we say here is based on formal and informal interviews, classroom observation, stimulated recall and repertory grid analysis. Details of these methods can be found in the report of the study(Olson, 1986).

## Computers as a New Subject

We can begin by looking in this paper at using computers to teach a new subject. Why say it is a new subject? First, the four teachers whose experiences with computers form the cases of this study(See Tables 1 and 2) see computers as a new subject that they will soon be expected to teach, and they say

| SCHOOL | SIZE OF SCHOOL<br>NO. OF TEACHERS | TEACHER<br>YEARS EXPERIENCE | CONTEXT<br>GRADE(S) |
|---|---|---|---|
| Bathurst Public | 655<br>35 | Mr. Heiburg<br>8 | half-day French Immersion<br>6 |
| Ellesmere Public | 330<br>17 | Miss Somerset<br>18 | classroom<br>3 |
| Wolsey Public | 175<br>12 | Mrs. Hughes<br>18 | library<br>k - 5 |
| Marlborough Senior Public | 630<br>33 | Mr. Owen<br>18 | classroom<br>8 |

Table 1 - Schools Doing Computer Awareness

| SCHOOL | AWARENESS ACTIVITIES | SOFTWARE | HARDWARE | SCHOOL SUPPORT |
|---|---|---|---|---|
| Bathurst Public | utilities<br>programming<br>word processing | Crossword Magic<br>Bank St. Writer<br>French verb and noun drill<br>Print Shop | Apple IIe<br>2 single disk drives<br>Apple Printer<br>colour monitor<br>green monitor | Principal |
| Ellesmere Public | low res.graphics<br>drill<br>designs | Apple Soft BASIC<br>MacPaint<br>MacWrite | TI Computer<br>Apple II+<br>Apple IIe<br>MacIntosh<br>2 Apple printers<br>Single disk drive<br>colour monitor<br>green monitor | Principal |
| Wolsey Public | low res.graphics<br>drill<br>word processing | Crossword Magic<br>Sticky Bear<br>Bank St.Writer | 2 Apple IIe<br>1 double disk dr<br>1 single disk dr<br>2 green screens<br>2 colour screens<br>2 Apple printers | Principal |
| Marlborough Senior Public | drill<br>word processing | Algebra 1,2,3<br>Bank St. Writer<br>Golf Classic | Apple IIe<br>linked to central CPU<br>single disk drive | half time computer teacher<br>computer lab |

Table 2 - Set up for Computer Awareness

that now is a good time to become involved. They would like to see the subject taught and would like to promote it. The subject is also new in the sense that there is no established Ministry of Education policy governing its place in the curriculum below grade 9, nor are there formal Board of Education policies. However, there are informal ideas circulating amongst these teachers which do influence how the new subject is defined. Computer courses are available from a local university which some of these teachers teach and which some take. Some of these teachers have offered in-school P.A. day activities and some have been involved in such activities. Computer Place, the Board computer centre, produces a newsletter which, at least indirectly, suggests what the new subject looks like.

The subject is also new in the sense that it appears to require every classroom teacher to have a set of expensive machines in order to do a good job teaching it. Few, if any, have as many machines as they think they ought to have. These teachers feel that they are having to operate the new subject with insufficient equipment and make do. Insufficient equipment is not new but it is difficult to substitute other activities for the computer; one book can be substituted for another and study prints used instead of a film strip but either you have a computer or you don't.

It is new in another, complex way. Computers can be used to teach about programming as car engines are used to teach about auto mechanics but computers can also be used to teach

with ; they are a teaching aid of potentially wide application - that cannot be said about car engines. The many potential uses of tne computer provide an ambiguous backdrop to the decision to treat the computers as a subject rather than as a teaching tool.

These "newness" aspects of the computer as subject are very much in the minds of the teachers we talked to who are using computers in this way. One way of looking at what they are doing is to see their practice as an effort to work out for themselves the problems posed by tne newness of the computer. We shall say more about this process later. It is important to say here that while the computer as a school subject is seen as new, how these teachers teach it is very much influenced by their ideas about which aspects of the computer should be given prominence in tne classroom and by their ideas about their role in teaching it. As we shall see, in some cases students are expected to teach themselves.

Finally, lest the distinction between teaching "about" and "with" computers seem cast in stone, it can be argued that any work on the computer contributes to an "awareness" of it and any awareness of it contributes to a greater capacity to think and to increase knowledge about something, and hence to some "subject" matter. The teachers we talked to did allude to these ways of looking at their work but only in passing, and with no great conviction about how persuasive these are as rationales for computer use. It would seem that unless these notions are more fully developed, they remain rather vague ways

of trying to bridge the gap between "about" and "with".

With these introductory comments, we can look more closely at what teachers are doing and why they are doing it. The teachers we are considering here teach either primary or junior classes except for one intermediate teacher. With the exception of one who is a librarian and has her computers in the library, all the teachers are using computers in their classrooms.

Status of Subject in the School

The teachers said that their own knowledge of computers in education was not extensive and that there was very little material available to guide them in their planning. Getting to know software was something they said they would most like to do but there was simply not enough time to do it. Miss Somerset said she was concerned about issues of scope and sequence in teaching computers as a subject and Mr. Owen made it quite clear that he wanted to know much more about what the curriculum for computers should be before he felt he could teach the subject to his class as a whole. He wanted a guideline with very explicit steps which would allow him to monitor progress by giving him something to test. He wondered just what ought to form the outline of the subject in the middle school and saw the subject now as a distinct "add-on" to his existing activities. Mr. Heiburg thought the subject should be recognized on the report card and be given a grade; this would be one way to show that it was being taught; that he

had to teach it.

All of these teachers thought that in-service education had a role to play in preparing teachers to teach computers as a subject. The main concern was with gaining access to suitable software; software that will help them run the awareness activities with the least amount of interruption and classroom dislocation.

Principals. All of these teachers' principals expressed concern about the educational value of the computer awareness activities and the extent to which student progress was being monitored. Their uncertainty here can be seen as a reflection of the uncertain status of computers as a subject in their school, the experimental nature of the methods used to teach tne subject and the lack of policy in the field as a whole. Given these facts, it is not surprising that the principals, not as immediately involved in the computer projects in their schools, might muse about the purposes to which these machines are put. None of the four teachers conducting awareness activities expressed similar doubts but all were aware that they were pursuing these activities against a backdrop of uncertainty about the uses of computers in education. All mentioned ways in which their work might link up with existing school subjects and with computers as a teaching aid but none made the links a central part of the way they talked about what they did.

How Teachers Are Using the Computer

Awareness. It is worth considering how computers are typically used for teaching "about" computers. One or two computers are set up in the room usually with two screens (high resolution green and low resolution colour), a disk drive, and a printer but there are variations. One computer may be in the hall; a printer may not be attached; only one screen may be available; two disk drives may be available. Sometimes the computer stays in the room; sometimes it is moved about. If there are two computers, they are often not of the same type.

These teachers describe their work as "computer awareness". Built into the way teachers talk about awareness are theories about scope and sequence in the new subject. Certain activities precede other activities, and certain activities are to be included at the elementary or intermediate grades while others must wait for high school. Miss Somerset, for example, has her grade 4 children use the computer to create pictures of things they first designed using graph paper. We watched Julie program her picture of a dog using Applesoft Basic. Miss Somerset talked about the appropriateness of such activities for junior children. Her approach to this was trial and error: see what was needed to help them get the idea and then see what happened when they went to the computer. Through her "experiments" she had found out more about the order in which she should present the information about programming and about what programming routines she could safely include so that most of the children

could get the idea and still create the picture.

Access to the computer in Miss Somerset's classroom is determined by a rota, which is a familiar device for ensuring equal access. She, like the other teachers, is trying to ensure that as many students as possible have computer awareness experience. Behind this idea lies a theory about how children become aware of computers: by being exposed to them. We might call this an "innoculation" theory: the more exposure to the machine, the more awareness will result. Awareness is developed through "hands-on" experience not through just being told about computers. "Hands on" experience is seen as a way to increase students' "comfort level" at the computer, a way to remove any fear of the machine that they might have. There are some similarities here to the way the use of science laboratories is typically justified by science teachers.

Attached to the awareness idea commonly is a theory about problem solving. Computer awareness leads not only to [how] to operate the machine but to an enhanced capacity to "problem solve". The software is seen as providing occasion for learning to manipulate the machine and for increasing the capacity to solve problems. In this way virtually any software can be used, whatever original purpose its designers may have had, including utilities designed for teacher use and word processing programs. The notion of "comfort level" also determines a similar use of software: a wide variety of software can be used, whatever its original purpose, as long as it is relatively "friendly".

Programming, either using Basic or LOGO, is seen as one type of awareness activity, as is the use of any software. Becoming "familiar" with types of software is part of the informal awareness curriculum. This includes learning how to evaluate and run software. Learning how to use peripherals is also part of awareness. Thus experience with joy-sticks, koala pads, modems, and other peripherals is considered to be part of the curriculum. Parts of the computer, the names of the various peripheral devices are items in the list of topics to be covered in the curriculum, in the same way that various operating commands in Basic are taught.

The four cases themselves, of course, yield many more details about how computers are being used as a subject. Perhaps the above might suffice as a brief overview of what teachers are doing. How do they manage to teach computers as a subject at the same time as teaching their other subjects?

## The "Teach Yourself" Approach

In all cases teachers are doing at least two things at once, at least some of the time. One computer, at best two, creates severe access problems for teaching the subject if access to the computer is thought to be the main way the subject should be taught. These teachers do think being at the computer is the way awareness is to be achieved and they have had to organize their classrooms accordingly. Students have access to the computer during class time, or during recess, lunch or after school or both. They have access according to a

rota, or through petition or both. There are a variety of patterns used but they are all directed at getting as many students on the machine, consistent with availability of the machine and the teacher's capacity to cope with the problem of doing two things at once or being available for computer activity support outside of class time when, typically, other school related tasks also make a claim on the teacher's time.

Doing two things at once is not new for teachers. Teachers have well developed strategies for doing two or more things at the same time and there are many occasions when these strategies are used; think of reading and math groups; of various kinds of self-selected project work at stations and so on. Teachers are used to monitoring these situations and satisfying themselves that productive work is being done. They are used to interpreting students' behaviour in terms of their need to intervene. They have been able to disambiguate various kinds of episodes associated with multiple activities in the classroom.

One strategy is to ensure that the materials that students work with are sufficiently self-explanatory so that students are independent of the teacher. The teacher has to ensure that there is enough direction given so that the materials really do function independently. There are quite complex judgements to be made here calling for considerable experience. With experience the teacher becomes habitually capable of making such judgements by quickly isolating relevent features of the materials and characteristics of the children, and deciding how

to proceed.

Without exception, the four teachers have used "teach yourself" strategies to incorporate the computer subject into their daily routines (see Table 3). The ways they have done this are interesting and can be seen in detail in the cases themselves; here we would like to comment on some general features of their strategies.

It is not surprising that the "teach yourself" strategy is used because computers are teaching "machines" after all, and a teacher knows that drill and practice software is intended to at least rehearse children in things they need to know even if it does not explain or make plain what they are doing. Software often comes with documentation about how to use it that teachers have had to use to teach themselves and it is a natural step to assume that children might be able to use these documents or, alternatively, use tutorials which might come with a program, as in the case of "Bank Street Writer".

There is a further, more compelling reason why teachers are interested in a "teach yourself" approach. They view the children they teach as members of a computer-oriented generation, at least as able, perhaps more so, than the teachers at learning how to use the computer. At least some of the students are viewed this way by some of the teachers. These students are relied upon to help the teacher, other students, and even other teachers. This help involves trouble shooting and, more importantly, peer tutoring

These computer "literate" students seem to know their way

| TEACH YOURSELF COMPUTER AWARENESS | DIFFICULTIES REPORTED |
|---|---|
| Subject goes on all the time | Machines scheduled elsewhere<br>Students away/unprepared |
| Students learn through programming | Program errors undetected<br>Students unsure of control procedures |
| Peers tutor each other | Students "debug" but do not tutor |
| Students share work in pairs | One student does most of the work |
| Students get help from documentation | Documentation too difficult to read |
| Access is a reward | Students bored with unsuitable software |
| Contact with teacher is minimal | Teacher needed to interpret syntax error messages, locate software |

Table 3 - The "Teach Yourself" Computer Awareness Routine

around the machine; they seem to be able to get things going and keep them going. Some of these students know more than their teacher about the machine. We met some of these students and we saw how they functioned in class. They would appear suddenly to help other students who were stuck; they would stay on and take over from students who had not quite got the procedures for programming graphics, for example; they wanted to talk to us about their interest in computers. They were attracted to the computer. There were perhaps five or so of these students in every class we visited.

There have always been students like these in class. They are enthusiasts who bring to school their special interests and share them there. What is unusual here is that some of these students are enthusiastic about a machine that is used to teach them and enthusiastic about what it can do. They have the time to explore the nature of this machine because they have one at home. It is not surprising that teachers who are teaching computers as a subject have the view that students can teach themselves. Some students are teaching themselves already.

There is a further and perhaps equally important factor here. time. All of these teachers expressed concern about the time it took to prepare themselves to use the computer as another subject in the classroom. The main burden was previewing software. Given the time it takes to do this and the idea that students can teach themselves, it is not surprising to find teachers having students appraise software. Mr. Heiburg and Mrs. Hughes both have students assess software.

In view of these teachers' interest in computers as a subject and in a "teach-yourself" approach to it, the nature of software preview becomes an interesting issue. If software is chosen primarily for "awareness" and primarily in terms of a "teach-yourself" approach, then certain kinds of software are going to be favoured: namely software which requires a minimum of teacher support and provides a maximum of student engagement.

LOGO has proved not to be a self-sustaining program in the eyes of two of these teachers. Mr. Heiburg said that the students had difficulty interpreting the feedback; he had let students tutor each other in order to overcome this difficulty. Mr. Mitchell said that the students find LOGO of interest at first but they grow bored with it once they have learned to "get this little turtle whipping around the screen."

All of these teachers spoke about launching the students off on their own through the use of supportive software. Their concern about software can be read in the light of the need for independent activity. Miss Somerset said that students did not read the instructions on the screen properly, and also that she wanted programs that manage instruction. Mr. Owen said that although they like math games, students get tired of the software he gives them and do not themselves initiate a search for something else. Mr. Heiburg found that some students had difficulty using utility programs he gave them because they did not know how to interpret "syntax error". He found that LOGO was not self-sustaining because students had difficulty using

the manual to learn how to do it. Mrs. Hughes said she avoids software with complicated instructions.

Student Reactions

Mr. Heiburg, for example, said that it is only because his class is keen and easy to control that he can operate a computer awareness program at the same time as he runs his french immersion program. With a more difficult class he would use much more structured software like drills, and use word processing and utilities less. Miss Somerset also spoke about effective control of the class. She finds that students are excited by their computer work and that this is not easily handled. She has to keep in mind the abilities of her students to learn the programming routines. She continues to speculate about this but tries to be optimistic. Mr. Mitchell found it impossible to run a concurrent computer activity in his science lessons because his class is not sufficiently attentive. Mr. Owen found that without a nucleus of computer literate students it was difficult to operate an awareness program. On top of that he found students were distracted by the presence of the computer and he had to reserve the computer for out-of-class time. Mrs. Hughes found that the children's capacity to read support documents affected her choice of software.

Miss Somerset found that it was difficult to use "Bank Street Writer" because students did not "read" what was on the screen; they would not follow the menu, perhaps because they did not understand what they were being asked to do: she

thought that "Bank Street Writer" might be too difficult for them. Similarly, she said that some children did not actually do the computer graphics they had plotted out on graph paper, also perhaps because they did not understand what to do. Miss Somerset thought that the grapning activity might not be justified. Without guidance in this matter, she was very much exploring this area on ner own. We saw students in Mr. Heiburg's class unable to use a utility program he had given them. He said that they "needed a more directed approach". That is, they needed more instruction in the use of tne utility before they could use it but access to such instruction is at a premium. The teacners hope to operate the awareness program with a minimum of teacher input.

The nature of the software these teacners use affects their capacity to operate on a minimal input basis. Because of their interest in computer awareness, these teachers wanted their students to learn how to program. Learning how to program is one of the central ideas nested within the awareness concept. Progamming took different forms: using utilities like word search which could be programmed; LOGO; low-resolution graphics; and Basic itself. Using these programs, however, requires more teacher support than the more friendly drill and practice and tutorial programs. Word processing also requires teacher support, especially if students have difficulty understanding the relationsnip between commands and text management.

It is not surprising that these teachers rely on computer

literate students to tutor other students and trouble shoot when needed. These students are available and they often know just what to do. We found that children who came over to help other students in difficulty tended, however, to take over rather than to tutor their peers. We had thought that the computer whiz student would pose a problem for teachers. We did not find this to be so, assuming of course, we have understood what these teachers were telling us.

Computer literate students seem to be necessary for computers to be taught as a subject in the way tnese teachers are doing it. These students provide a model for the rest of the students; someone who can easily use the computer and show others how to do so. They can provide the teacher with a sense tnat something is being achieved that is associated with their awareness program. These students can program, they can produce interesting and relatively sophisticated products from the computer. They can share enthusiasm for computing with these teachers who are, each in their own way, enthusiasts.

"Teach Yourself" in Action

Although the teachers try to make sure that children at work at the computer teach themselves, tnis does not always happen in practice. The programs tne children use do require teacner support. Without that support students are bound to get off on the wrong track - it is in the nature of programming and word processing. We saw two examples of this: one girl had entered graphics co-ordinates incorrectly. She had wasted

about one hour doing this before the teacher discovered the problem. In the word processing case, the student did not know how to use the return key to paragraph, resulting in a print-out quite unlike what she had planned.

One approach to providing support is to give the class as a whole lessons on how to use the computer. Miss Somerset, for example, gave lessons on control keys to be used in graphics programming. Mr. Owen's students were given lessons on the computer by the school's computer resource person. Mr. Heiburg took his whole class through an introduction to the computer program by demonstrating it; Mrs. Hughes had all the classes come to the library where she gave them an introduction to the machine.

In spite of these efforts to prepare children to use the computer, the teacher still finds his/her self in the middle of two lessons; trying to do two things at once. It had become clear in our preliminary interviews that teachers were very much concerned about being able to cope with doing two things at once; even Mrs. Hughes who works in a library.

Mr. Heiburg said, "Your attention is bisected, trisected and the class has to work with a certain level of freedom." Miss Somerset found the noise of the printer distracting, and she found that when she leaves the class to help the computer "class", students start talking. Mr. Owen found it distracting to have students working on the machine, and that students rushed their work so that they could get access to the computer. He found it easier to work with smaller groups in

situations where he could concentrate entirely on the computer.

Probing Classroom Practices

We talked to the teachers about the apparent difficulties they were having in running the "teach yourself" approach. We were concerned to understand why they persisted with the approach in spite of the difficulties. In order to do this we presented the teachers with a set of elements which we felt characterized the situation in which they found themselves. We asked them to group these situations and explain to us the basis of the groupings.

From our analysis of their comments about these situations we gained an insight into the ways these teachers thought about the demands of teaching a separate computer subject.

The teachers tended to look at situations in terms of whether or not they had to intervene or could let the situation resolve itself; whether delays or interruptions were due to complex student characteristics or relatively straightforward mechanical problems; whether delays and interruptions could be quickly disambiguated or would require an extra effort; whether existing rules applied or new ones were required; whether routine responses applied or judgements had to be made.

Teachers seemed concerned about how much time it would take to unravel and resolve a delay or interruption episode. We had expected that worries about machine problems would dominate how teachers construed delays or interruptions but we

found that they were more concerned about having to face complex student reactions to situations, like impatient and bored students or students getting wrong answers or disagreeing with answers; students whose actions were saying something complex about their response to activities planned for them and requiring of the teacher that the actions be disambiguated.

Now these are not concerns that attach immediately to using the computer; they are fundamental but the computer can add an extra dimension to the ambiguity of an episode because it is not clear just what is "bothering" students who for some reason or other do not "get on with it". Of course, as time goes on, and situations once ambiguous can be treated as routine, teachers will find computers a less perplexing element in the situation.

Perhaps these points can best be illustrated with reference to Miss Somerset's concerns about student collaboration. She felt that because computer work encouraged students to help each other, indeed even required them to collaborate to keep going, they might think that they could collaborate on tests or on their seatwork. Collaboration is an ambiguous activity in Miss Somerset's view. When, she asks, are they going too far by making too much noise and sharing work they should not be sharing?

Doing two things at once is made more difficult for these teachers because, unless the teacher has extensive experience of students' reactions to the software being used, time is required to disambiguate delays and interruptions. Teachers

normally have this kind of familiarity with the self-directed activities they give their students but this familiarity is built up over time. For example, certain types of self-instruction kits are often used by teachers and, over the years, they become familiar with how they "run". Getting to know how software runs is the same; it takes a long time and much experience. These teachers have not yet had this experience. It is interesting that Mrs Thomas, a teacher who uses software for drill and practice, used a familiar kit, Language Master, as a touchstone with which to compare her experience with computer software. She compares the ways in which students react to the Language Master drills with the way they react to software.

We could see from our analysis of the teachers' comments about managing the computer that they are using an approach to computers as a subject which minimizes the demands on them. Nonetheless, as it turned out, many demands had been made which caused problems, yet when asked what the benefits of persisting with the approach were, they said that they derived much satisfaction from the students' enjoyment of the computer activity, in spite of the difficulties.

## Why Computers as a Subject?

We asked the teachers to tell us why they thought computers should be a subject. They said that studying

computers, like driver education, is intended to give students something they can use in the future in a tangible way; to get a job, to be able to use computers in private life. Miss Somerset saw them this way, as did Mr. Owen who thought that students would need to know about programming. Mrs. Hughes wants her students not to fear computers, to be able to use them to make their lives easier. Like Mr. Heiburg, who feels that working on the computer provides students with a way of organizing their thoughts more accurately, they all stressed thinking skills. Mrs. Hughes talked of "thinking skills" achieved through experience with low-resolution graphics, although she said she had no way of telling whether or not such skills are actually improved through experience with computers.

Beyond the vocational and cognitive justification for including computer literacy in the curriculum (which we did not find highly elaborated), there were reasons more to do with making the classroom a more interesting and enjoyable place to be. Miss Somerset said that "it was a thrill for the students when they found they could do something different, something new, something creative". Mr. Owen remembered working on his computer course assignments with some of the students and sharing with them a common task. They were interested in what he was doing and were able to show him what to do. Mrs. Hughes said that her students enjoyed their computer experiences and "the kind of pleasure they get out of it gives me pleasure".

What the computer has to offer is open to many interpretations. These teachers are hopeful that there will be

important benefits for their students in the long run. In the short run, they seem to be saying that computers add a new dimension to their teaching; something their students can look forward to and that they can give them.

Where Next?

When we asked these teachers what more they wanted for teaching their subject, they wanted, above all, time to prepare themselves. They also wanted more guidance; in fact they wanted a guideline which would outline the scope and sequence of their subject, although they were aware of the many unanswered questions about what was appropriate at their grade level. They saw their projects as contributing to an understanding of what the computer subject should look like in the elementary school.

These teachers all want to have a computer in their classroom; they want it to be part of the "furniture" as Mr. Heiburg said, but they differed about who they, as teacher, were in relation to it, although all were uncertain about this question. Mr. Heiburg wanted his school to have a computer resource person but did not want that to mean that he would not have a computer in his room. Mr. Owen, whose school did have a computer resource person, wanted his students to be trained by that person so that they could use the computer in his room with minimum input from him. Miss Somerset also saw the computer as part of the furniture and she would like to retain the role of expert computer teacher. Mrs. Hughes saw her work

with computers as part of her work as a remedial/enrichment teacher and as a librarian. She has continued her remedial/enrichment role largely in terms of offering computer awareness to students who come to her. She is operating as a computer subject teacher but within the broader remedial/enrichment designation. She saw herself as a computer resource person, informing other teachers about available software. In effect she has taken on tasks that one would associate with a computer resource teacher. In fact, her activities are very much like those of Mr. Mitchell at Marlborough School who is half time computer resource and half time science teacher.

The teaching of computers as a subject raises issues to which we have already alluded. At present, these teachers do not have a guideline to follow, that is, there does not exist a curriculum for the subject. Put this way, what does not exist is a rationale for including computers as a subject in the elementary school. Justifying computers in the elementary school raises questions about the whole curriculum. Where do computers fit in? There are, of course, various arguments to be made for computers but these are usually made without considering the whole curriculum. These teachers make it quite clear that they are "doing computers" as an additional subject; fitting it somehow into an already full program of activities. How will time be made available to include work on computers? There are critics of the elementary school who say that science is not given enough time, how will time be found for computers

as a subject? These questions are based on a concern to understand the status of computers in he curriculum, and it is to the larger curriculum issues that we now turn in the next section of the paper.

## CURRICULUM QUESTIONS

In each of the four cases in which computers were used as basis for learning a subject, tne teachers stressed programming as the definitive activity of the s bject (see also NEA, 1983; Amarel, 1984; Ragsdale, 1982). Stu ents studied the subject by being at the computer; their acces was controlled by a rota system.

Programming took various forms ut especially making low resolution graphics and using utilit es to produce book titles and crossword puzzles. In two cases teachers thought tnat experience with various types of soft are was in itself a way to create computer awareness.

The teachers did not develop a formal syllabus for their computer awareness activities as such but were guided by the process of programming itelf: what tne children need to know to operate the computer on their own. The informal syllabus enabled the teachers to pursue their goal of a self-taught subject. Occassionally whole class lessons were given on key controls but, on the whole, the subject was taugnt through experience at the computer. How much time children actually spent at the computer, and hence studying the subject depended on how many computers were available, how long each session at tne computer was, which students worked in pairs and whether or

not they were able to take their turn or not due to attendence or denied access due to classroom benaviour. As well as formal access, there were chances for informal access during recess, lunch and after school. In this way, two children in the same class might end up with quite different experiences of computers as a subject.

Teacners think that developing awareness is a direct function of time on tne computer; the more time students spend at the computer the greater their awareness of it. Awareness was expressed in terms like comfort, muscle control, knowledge of commands, typing skills, thinking skills, creativity. Such awareness is important, tne teacners said, because computers are a new and important part of everyday life and employment.

These teachers think that computer literacy is achieved by learning how to control the computer and that what is to be learned can be found in the operating manuals, for example, the Apple [Owner's Manual]. Some teachers also used the "Apple Presents Apple" as a guide to computer use. Documentation accompanying various types of software is another source of guidance available to teachers

One of the teachers has a computer at nome, reads computer journals and does programming herself. Another meets regularly with otner computer users. All nave taken computer courses offered either by the ministry or tne board, or botn. Two teachers have previewed material at Computer Place, a computer services located at the board. Overall sources of support identified by tne teachers are outlined in Table 4.

| SOURCE | FREQUENCY OF MENTION | % OF MENTION |
|---|---|---|
| Colleagues | 6 | 23 |
| Visiting computer place (teacher centre) | 4 | 15 |
| Board computer course | 2 | 7 |
| Reading computer software documention | 2 | 7 |
| Previous classroom experience | 2 | 7 |
| Helping other teachers | 2 | 7 |
| Magazines | 1 | 3 |
| Contact with developers | 1 | 3 |
| Other courses | 1 | 3 |
| Tutorials | 1 | 3 |
| Conferences | 1 | 3 |
| In-school computer course | 1 | 3 |
| Total | 24 | 100 |

Table 4 - Sources of Teacner Preparedness

These teachers are constructing a curriculum from tneir experience of computer courses and documentation available with tne computer and software, as well as from tneir own experience in learning how to program. The computer subject seems to be almost entirely defined in terms of learning how to program tne computer and operate various types of software. Generally Basic is preferred to LOGO as a way to introduce students to beginning programming. No systematic use of LOGO was seen in their classrooms.

The teachers found it difficult to teach the new subject for a number of reasons. Firstly, tnere are of course no Ministry guidelines for computers in the elementary scnool, neither are there board guidelines. Secondly, teachers found it very time consuming to review tne documentation they did use as a basis for computers as a subject. Thirdly, with just one or two machines, teachers wondered how they could reasonably teach computers as a subject at all in any fully developed way. All wanted more machines and two thought that there should be a computer expert teaching the subject, with the teacher playing a supporting role (see also Lartner, 1983).

The subject in the curriculum. There is an interesting tension in what these teachers are trying to do. They think that computer experience ought to be a part of the students' education but they are not quite sure what form the new subject really ought to take, nor how it could be included in the whole curriculum. As they see it, what they are doing is an

unofficial, extra subject and they are an unofficial teacher of it. The marginal status of the "subject" is clear to them, yet they echo the quite common view in their board, and amongst administration and parents generally, that computer awareness is a "good thing".

It may be a good thing but its position in the curriculum in the elementary school is not clear. As it stands, computer awareness is an additional activity which teachers voluntarily take on and insert into the school day as they can. A computer station functions during teaching time based on a rota and less systematic access occurs at other times.

Teachers give their time voluntarily to preparing work for in-class time and to monitoring students during out-of-class time. In return they receive satisfaction from offering their students a variety of experiences which the teacher values and the students enjoy. For the library teacher, matters are a little easier: the computer subject becomes one element of the resources available in the library. In fact, the library setting might be seen as a transitional arrangement interposed between the classroom stations and the computer lab. These teachers want the computer subject established in some form and they want to play some role in teaching it.

The important curriculum question is whether the subject should be established in the curriculum, and if so, what form should it take. What do the experiences of these teachers have to say about these questions? The research report is not the place to argue for or against the establishment of computers as

a subject in the elementary school. If one wants to argue for having computers as a subject in the elementary curriculum then a number of questions do arise from this research which we consider now.

1. These teachers have found it difficult to do more than introduce the rudiments of programming given the time and resources they now have. If they were asked to introduce computers but without a clear mandate to take time away from some existing activity, how could they do more than they are doing now? Is what they are doing now enough to justify establishing computers as a subject? (see also Ont. Min. of Ed., 1983).
2. If they were given class time but no additional equipment, how could they do more, given that "hands-on" experience of the computer is considered to be the way computers as a subject is to be studied?
3. If the preview of computer software is as time-consuming as teachers say it is, where are teachers going to find the time to become knowledgeable about and proficient in the use of software?
4. Given the demands on teacher expertise just to run the add-on activity they do now, is it realistic to expect teachers to take on an area which demands a high level of commitment and training?
5. If "computers" becomes a subject taught by specialist teachers with the commitment of time and resources that this implies, how is this to be justified given the arguments

that can be made for improving the level of french language and science teaching in the elementary school, for example? How can computers as a subject be justified in relation to the whole curriculum and the existing areas which are thought to need additional resources?

Justifying computers as a subject. These are some of the questions that emerge from the present cases in which the computer is taught as a subject. Some may want to argue that computer awareness is best thought of as a desirable by-product of using computers as an instructional tool although some nave argued against that (Ragsdale, 1982). The main point to be stressed here is that the status of computers in the curriculum remains curiously vague. Arguments for computers as a subject in tne elementary school (eg. Clements, 1985; Riedesel and Clements, 1985) say nothing about the whole curriculum, only that computer literacy is important because computers "will be used in all areas of society, including education". Their argument goes on to stress that children can learn from computers and shifts in focus from learning "about" to learning "from" computers. They say that computers can help children learn, and therefore children should know about them. Such an argument really does not face up to tne need for an independent rationale for computers as something to be learned [about].

These issues remain entangled in this quite common approach to justifying computer literacy as a subject for scnools (see Amarel, 1982; Fisher, 1984). The justification

for learning with computers flows from the subject in which they are used. They are a tool whose purpose is defined by activities beyond simply studying the tool. Here issues about the whole curriculum are not critical because, for example, computers might help children learn English composition better but English composition is already part of the curriculum.

But learning about computers as a subject in its own right is much more problematical and much harder to argue for. Curriculum time is a scarce resource; large investments in computers involve scarce dollars. How much time and money should be invested in computers in education? Is a vocational argument going to be fully persuasive? Such an argument might be that schools should prepare children for work. The work world requires computer expertise so school should provide this expertise? Or are there educational arguments to be made? For example, computers alter our way of life, our culture. Students should understand our culture and so they should understand the impact of computers on our culture; they should do this as a new subject rather than incorporate topics related to computers within existing subjects. Is this persuasive? How can computers be justified as something to be learned about and, if they can be justified, how can they be justified as the basis of a separate elementary school "subject"?

Fully developed, persuasive arguments for either of these views do not yet exist, as far as we can tell. We do not deny that such arguments could not be made. Indeed, we think they should be made as a basis for curriculum development and

teacher education if computers are to be a subject in elementary education.

There are two threads in existing arguments tnat do need to be untangled. Arguments for tne vocational benefits of learning about computers make certain assumptions about the functions of schooling; ones which have to do with the socialization work of the school. How far should this function be promoted? If the school pursued all possible socialization functions there would be no time for the critical, reflective activities associated with the educational functions of scnooling. This is not to say tnat one or the other function ought to exist to the exclusion of tne other; only that tnese functions have to be balanced.

Educational arguments can be made for learning about computers which stress matters to do with the role of technology in our lives; with privacy; with the control of tecnnology and so on. These topics, of course, could be dealt with within existing subjects. It would look as if the main burden for creating a new subject at the elementary level would fall on the vocational strand of the argument, in which case, one would have to look at the contribution early experience with microcomputers could make to vocational preparation.

Whatever decisions are made about the status of computers as a subject, tnere is a complex interaction between how the subject is rationalized, what resources are to be made available, what teachers can realistically do, what the impact on the rest of the curriculum will be, and what the overall

educational advantages will be (see also Golby, 1982). It is hard to see how it is possible to consider computers in the absence of a discussion of the curriculum as a whole and how that curriculum is intended to work in an educational way. It will be important to place the computers as subject in the elementary school in the broadest possible curriculum perspective, while at the same time attending to what teachers who have experience with the subject have learned as a way of assessing what realistcally might be accomplished and if that is enough to make it worthwhile, establishing the subject.

Problem-solving. These teachers place a strong emphasis on problem solving, in addition to the vocational value of learning to program the computer. Attaching the label "problem solving" to various school activities is not unique to the computer. Numerous school activities are said to ennance problem-solving skills. The difficulty with this rationale is that it is not clear in the computer context, what problem solving skills are, how computing contributes to such skills and what evidence exists that such skills are indeed developed. If problem solving is going to be used as an important part of the educational justification for computers as a subject, then the term itself needs to be elaborated in relation to some theoretical understanding of how problem solving and programming might be linked, and in relation to research evidence which indicates that there is reason to think that

problem solving capacity and computing experience are linked. At the moment, use of the term seems to be quite vague.

Teacher Education Perspectives

Matters of curriculum and teacher education are closely linked. How the computers as subject will be taught - especially now when guidelines are absent - very much depends on what teachers know how to do with computers and on the different types of lessons they are capable of organizing. As in other subjects in the curriculum, there are questions about subject matter knowledge and about pedagogy at issue here, made quite complex by the indeterminate status of the subject.

From what we have seen in the case schools, there are clearly many teacher education issues at stake: teacher knowledge of programming; assessment of software; evaluation of student learning and of the program; methods of instruction using computers. We shall refer to all of these.

If the computer subject is going to be defined in terms of programming activity (and this is how these teachers see it), how skillful do teachers need to be in order to teach elementary school children the rudiments of programming? And what programming languages are to be used? These teachers prefered Basic to LOGO as a way of structuring beginning programming. One might argue that these teachers did not know enough about LOGO to make an informed choice, and indeed, as far as we could tell, none of these teachers had had much experience with LOGO. The fact that, based on the experience

they did have, they prefered Basic indicates something about what they think beginning programming should be like. They gave the impression that most children were not willing to explore LOGO on their own, and that use of LOGO would have required them to provide more support than they could have managed. On the other hand, elementary exercises in Basic were more self-supportive, but also created a demand for teacher support which they found difficult to meet.

Our point is that the teacher education question hinges very much on the way computers as a subject is set up in the elementary school. If the classroom teacher is going to operate with one or two computers in the home room, then what the teacher will need to know is quite different from a situation in which computers is a specialist subject taught by a trained computer teacher in a lab. The difficulties attached to the latter situation are of a different and lesser order from the classroom situation which we shall attend to here.

Let us imagine that a grant of time and resources is to be made in order to establish computers as a subject at the elementary school: how might classroom teachers prepare themselves for this responsibility? First, we must ask, what have these teachers done?

Teacher preparedness. First, all of them have taken courses on computers in education; all have been given initial assistance from other teachers in their schools. In fact, an expert colleague is a major factor in initiating and sustaining

teacher interest, as far as we can tell from these cases. They all feel that more training in ways to use the computers in the classroom is necessary,

Second, these teachers have taught themselves how to program to some degree, and how to run and assess software. They have devoted considerable personal time to this process. As a result, they are familiar with a range of software types, as well as with the elements of Basic.

Third, they made room in the classroom in which to experiment with computers as a subject. It is important not to lose sight of the idea that they were experimenting with a new subject and with unfamiliar resources.

Fourth, as time went on, they talked to other teachers in their school about various problems in using the computer and received peer tutoring.

Fifth, they received institutional support from the board and the school in diverse ways: newsletters, visits from and to the board, encouragement and various forms of support from their students and the parents.

All of these activities have enabled these teachers to launch a particular approach to computers as a subject - an approach which can be seen as an assimilation in practice of training opportunities, computer and software resources and time. The approach they have used is a creative response to these conditions but is also limited by these conditions. What might be possible given that conditions could be amplified? In saying this it is important to recognize that teacher education

issues cannot be separated from resources and issues of time.

The rota-based "teach yourself" approach that these teachers adopted represents, perhaps, a datum from which more extensive activities could flow (see also Fisher, 1984; Amarel, 1983; Judd, 1983; Scanland and Slattery, 1983). Their approach is a datum in the sense that it represents an adaptation of an existing method of diversifying classroom activity while minimizing demands for teacner support - it is a "minimax" solution to a problem, if you like. The point here is that other solutions might be possible, indeed desirable, if conditions were improved. What might these be and what are the implications for teacher education?

An agenda for teacher education

1. If there were more time, teachers could use whole class teaching in order to expand subject activity beyond introduction to programming (see Phillips et.al., 1984). This presupposes that the teachers have access to curriculum ideas from which to develop classroom activity and th y know how to translate curriculum ideas into practice. In general, they are likely to be experienced at this but there may be specific areas of difficulty, such as using the computer for whole class teaching.

We nad expected to find teachers using the computer as a focus of interest for wnole class teaching but found such activity to be rare. With a limited number of computers teachers could engage the whole class in various awareness

activities by using a computer at the front of the class. This assumes that teachers have access to high quality, large monitors - equipment we did not see in the schools we visited. This also assumes that "hands-on" activity is not the only mode through which educational objectives could be achieved.

Teacher education activity might involve both an analysis of computer-based whole class teaching and the study of topics in computer literacy which go beyond work at the computer. As things now stand, teachers do not have an adequate curriculum basis for developing a computer literacy program, nor personal and classroom time to develop a range of teaching methods. Given the expressive goals teachers appear to favour , the present "teach yourself" approach may be adequate but if the computer activity is intended to develop particular, evaluated competencies and understandings, then alternative pedagogies and a broader conception of the subject will be needed.

Whole class teaching, using the computer as a point of departure, would require of the teacher skills in discussion leadership, in promoting problem solving and moral arguments, as well as the technical capacity to operate the computer while teaching (see Fraser, undated). These are quite high level competencies.

2. With respect to divergent thinking, teachers would need to have some framework for developing cognitive capacities like problem solving, and for assessing learning. Clements (1985) presents such a framework for preparing young children for programming.

It is not clear, however, just how programming activity is linked with psychological theories about the cognitive processes involved in problem solving. This likely would be an important area for in-service course design, were the cognitive aspects of programming to be stressed in a computers as subject approach. It would form an important basis for developing approaches to student evaluation.

3. Teachers in this study were concerned about the time it took to preview software and to learn to manage software in the classroom. Clearly how to preview software is an important skill in this context, and there is much development work needed here as a basis for pre- and in-service course design. These teachers were keen to obtain a variety of software and peripherals but unsure, it seemed, about how to build these elements into a systematic study of computers. Without a developed curriculum for this subject, selection of materials must remain haphazard and developing criteria without a curriculum context itself must also remain haphazard, since the curriculum itself provides important criteria beyond technical issues to do with software and peripherals. Clearly the presence of a curriculum is a pre-requisite for developing teacher education courses including courses on the selection and use of computer resources.

4. These teachers were very much interested in how children responded to computers and found considerable satisfaction in the positive responses of some children. Children's responses to microcomputers - both socially as a part of classroom life

and individually in matters such as practice, persistence, interest, attitude and so on - are an important topic for teacher education. The point here is that certain children respond quickly and avidly to opportunities like microcomputers; others have a more diffident reaction, and questions about gender differences always exist (see Ridgway, 1983). It is natural that teachers will be influenced by children whose interest is strong but the full range of student response needs to be understood. Now this is a constant problem for teachers, who are generally adept at dealing with it, but the advent of microcomputers may pose special problems which need careful monitoring. We think here of fairness in access to scarce resources; sharing in paired use of computers; effectiveness of peer tutoring; monitoring progress; teacher support for different types of student problems; students' ability to deal with abstractions related to computer control.

At the moment teachers are focusing attention on general matters such as overall class control, noise distraction, protection of equipment, evidence of high interest. They are evaluating their program in these terms. How to use such elements is certainly an important matter for in-service education but, if the computer subject is established, the detailed responses of individuals, pairs and small groups will need to be considered, as well as the ways in which teachers now evaluate their programs. As we saw, teachers operated the "teach yourself" approach; their concern was to minimize the

support they had to give to children so that they could conduct work in the formal curriculum and run an extra subject as well.

Establishing the subject will require teachers to increase and differentiate their support for children as they engage in a more varied climate in which to learn about computers. How to do that with limited resources might be the most important item for teacher education agendas.

As we said, teacher education and curriculum are bound up together. How the computer as subject is conceptualized in the elementary school will have an important bearing on the agenda which is set for teacher education. The experience of these teachers is clearly the basis for their in-service education. They see that this is indeed one of the values of their willingness to experiment on a voluntary basis. They are able to profit from their own experience and they are looking to discuss that experience in a systematic way in the context of a defined curriculum for computers as a subject. We have tried to point out in this section some of the curriculum issues that emerge from thinking about computers as a subject and, from there, to consider what challenges teachers might have to face if the subject does become part of the educational functions of the school.

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