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ABSTRACT

In order to get a comprehensive view of the problems and present development of the transferability to other locations of computer-based learning materials, it is necessary to examine short-range versus long-range viewpoints and the distinctions between computer-related aspects and those aspects associated with innovative learning and teaching techniques, using as examples present computer systems. With regard to short-range computer aspects, it is determined that the more systems the computer-based materials can run on, the less interesting pedagogically the materials are. Major problems regarding short-range innovative teaching aspects are political and sociological or involve instructors learning whether available materials are suitable for their course and reliable. Due to the changing computer technology, when we consider the long-range point of view, no computer aspects of transferability are important. However, the long-range view of innovative learning aspects poses problems with the marketing of future materials, the development of new materials based on the existence of the computer, and new modes of education. (CWM)

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TRANSFERABILITY OF COMPUTER-BASED LEARNING MATERIALS

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An important issue for developers of computer-based learning materials is the one of transferability to other locations beyond the campus or location at which the initial material was developed. Much discussion goes on about this problem, informally and in the literature, but much of this discussion appears to be based on very simplistic solutions, which do not examine the full range of problems associated with transferability. The present paper takes a broad viewpoint with regard to such transferability, delineating some of the factors which are often overlooked because only a piece of the total problem is being considered.

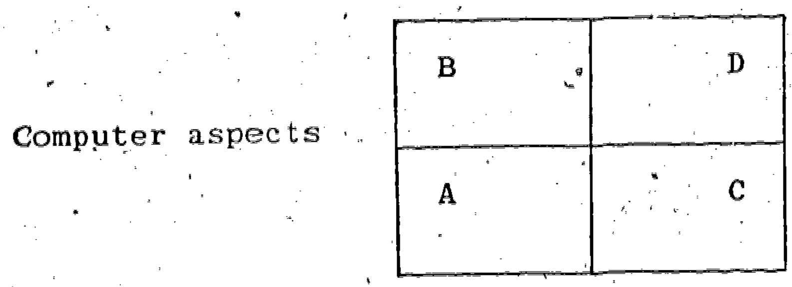
Two Dichotomies

This discussion of transferability is based on the two separate dichotomies, important in getting a comprehensive view of the problems and prospects for transferability of computer-based learning materials.

The first distinction I wish to stress is that of a short-range versus a long-range point of view. That is, are we considering immediately transferring materials within, say, the current academic year or are we discussing a more long-range prespect, the eventual widespread use of the materials developed in a particular location, over a period of many years? Although I am treating this distinction between immediate and future transfer as a dichotomy, it clearly, as with all such artificial dichotomies, is a continuum. It will be convenient nevertheless to make this separation.

A second important distinction to be made concerning transferability is that between the computer-related aspects and those aspects associated with innovative learning and teaching techniques. The first aspect is concerned with the technical problems of getting the materials running on systems Y, Z, and Q after having been developed on system X. The second aspect concerns the problems facing any development of new learning and teaching materials when those materials are spread beyond the institutions in which they are initially developed. Solving the first problem by no means furnishes a solution to the second problem. Thus, it is quite possible that the materials may be made to run successfully on a particular computer system, but that no faculty members at that institution will make any use of the material.

These two dimensions are independent. We can perhaps best illustrate the situation by plotting them along separate axes as follows:



As the diagram indicates, even with this rather simple-minded pair of dichotomies we have four separate sets of problems to discuss; Problem A involves short-range computer aspects, Problem B involves short-range innovative teaching aspects, Problem C involves long-range computer aspects, and Problem D involves long-range innovative teaching aspects. Tactics which may be good for one of these categories may not be good for another! A full discussion must take into account all of these possibilities.

I intend to consider each of these categories separately, both in terms of our present state of development and in terms of the difficulties and problems associated with them. I shall also point out in certain cases limitations brought about by focusing too heavily on one or the other aspect of transferability.

Short-range Computer Aspects

Most of the current work concerning transferability falls in this category. Probably the best example of a careful treatment of the problems in this area is seen in the activities of CONDUIT; many others cases can be mentioned.

One "standard" solution to the problem of short-range computer aspects is to write in a standardized form of the most commonly available languages. This, for example, is the tactic taken by the Computers in the Undergraduate Science Curriculum in England. Another possibility is to prepare the material in several commonly available languages. John Merrill's Book, Computers in Physics, uses both FORTRAN and BASIC, and Introductory Computer-Based Mechanics II, available through CONDUIT, presents each program in FORTRAN, BASIC, and APL.

Two difficulties present themselves with regard to this standard language approach. First, very few languages have effective standards. Perhaps the most standardized language is FORTRAN. Here, in addition to the ANCII standard, a more restricted standard is available as defined by a program checking program developed at Bell Laboartories, the PFORT standard. It is this standard which is employed by CONDUIT for FORTRAN. If a FORTRAN program satisfies PFORT and does not run on a particular FORTRAN, that FORTRAN is likely to be rather peculiar.

The standardization problems with BASIC are considerably more confused. Existing BASICs, even from a single vendor, differ greatly. Such terms as "standard BASIC," or, more commonly, "Dartmouth BASIC," although extremely widely used, turn out to have almost no meaning at all. Almost every BASIC refers to itself as "Dartmouth BASIC," yet as the Dartmouth developers point out, almost no other BASIC is compatible with current Dartmouth BASIC. For some years a committee has been at work on a standard for BASIC, but this committee has agreed only on an extremely minimal standard, not covering many of the features of BASIC in common use such as string handling and files. CONDUIT has also commissioned studies in this area, and a group on England has also developed such a minimal standard.

APL initially exhibited a much higher degree of standardization. For a while there <u>was</u> only one APL, the IBM program product. Almost all the later APLs have included this substantial portion as a subset, so this initial form has served as a de facto standard. But beyond this level, APLs have begun to diverge considerably. Even on IBM equipment several variants are in common use, including a privately developed version, APL PLUS. APL systems from other vendors depart in significant ways from these IBM implementations, particularly with regard to file systems.

These language factors become even less satisfactory with regard to ease of transferability when we consider graphic capabilites.

Although one terminal is most commonly used (Tektronix) other terminals are in use, and each demand different graphic code. Several incompatible graphic additions to APL have been designed; a committee is investigating the possibility of graphic additions to BASIC, not yet implemented in most systems. Because I consider graphic capabilities to be extremely important in computer-based learning materials, almost essential in most areas, graphic transportability problems are serious.

Another aspect comes in when considering standard languages, the inefficiency of the code. Thus, if we write APL graphic code so it works on <u>everybody's</u> APL, as does Tektronix, this can be achieved but only at the expense of some inefficiency. This is often a nontrivial difference. While this inefficiency may not be an important factor if the materials are only run with a few students, with usage in large classes it can be disastrous.

For the individual who is concerned with what will run on many other current systems, in relatively brief periods of time, these issues of languages are certainly important. As the programs become more and more responsive to student needs, and so more complex, and as they resort to more and more exotic languages, the work associated with moving them to another system becomes greater. It is significant that the programs that CONDUIT distributes thus far are the <u>simpler</u> materials that have been developed.

But a completely different side to the question of the use of standard languages as a technique for achieving compatability must be considered. An individual project that decides in favor of a particular standard language for all of its materials automatically <u>cuts off</u> some, often many, of the pedagogical options that are available to it.

Thus, someone writing in a BASIC that will be supportable on a great many different machines will avoid the use of many string inputs and so will not write materials that involve extensive input of this kind, even though pedagogically desirable in a situation being converted. Furthermore, a BASIC user seeking wide transferability for learning materials will avoid the use of files or overlays, since these facilities are likely to differ from system to system; thus, the programs will be relatively short, not the longer programs that exemplify some of the most interesting material available today.

I have, in my own personal experience, visited a number of projects of this type where, if one raises the question of "Why don't you do so and so?" the answer is typically an answer that depends on features of the language rather than on pedagogical choice. In these cases the desire for transportability is an important limiting factor in the quality of the materials.

I want to summarize my views on this issue with a statistical statement, a statement that does not necessarily apply to individual programs, but is, I believe, applicable in a general sense. Again it should be considered that I am looking at the short-range point of view, and the computer aspects only. Here is the statement which I will call Bork's First Rule:

THE MORE SYSTEMS THE COMPUTER-BASED MATERIALS CAN RUN ON, THE LESS INTERESTING PEDAGOGICALLY THE MATERIALS ARE.

Short-range Innovative Teaching Aspects

Just because materials can "run" at a given school is no guarantee that students will see them in classes or have any access to them at all. Faculty who know that these materials are available may choose not to employ them; many teachers who <u>might</u> use them may not even know of their existence. The problems are similar to the difficulties that we find generally when we move a new teaching idea from its original developer to a completely unrelated environment. Some additional problems appear, because the computer resources available may be limited; further, accounting procedures or shortages of facilities may make it difficult for students to access the necessary computer resources. Very few schools have currently the resources for widespread utilization of the computer in learning.

One major problem in this area is that of instructors learning whether available materials are suitable for their course, or whether they are reliable. The CONDUIT review system recently initiated gives one mechanism for solving the problem of reliability. Materials under consideration, after a preliminary screening, are sent out to several reviewers, so only materials that are technically sound and pedagogically useful will be recommended CONDUIT advertises their availability and serves as a source. Instructors will still want to look at the materials to see how well they fit into their course structure. If printed materials contain only a few programs, no particular problems are presented.

If the materials are interactive computer dialogs, meaning conversations with the computer, the difficulties can be greater. Because such materials are not easy to transport in the technical (computer) sense, CONDUIT does not as yet review them, although it is considering the problem. Further, while the instructor can easily browse through a book under consideration as a text, it is much more difficult to do this with a long and involved computer program, offering many different tracks for students. The design of some programs is more conducive to browsing than others, particularly if some aspects of learner control are present; but in general the instructor has difficulty examining dialog materials.

Many of the problems in this area of short-range innovative teaching aspects are political and sociological, needing very different mechanisms to solve them than the problems associated with the computer aspects just discussed. Often learning materials are put on a particular system by the computer facility itself, under the assumption that faculty and students will then flock to use them. But they may not even know of the existence of the material! If the faculty members in a particular academic area were not involved in advance in the decision to place the materials on the computer, the chances of widespread use are markedly lower. Our experience with sending our materials to other institutions with similar equipment, where the computer aspects of transferability are much reduced, shows that it is almost essential, if we are to see any use, to involve teachers in the decision to make the dialogs available.

One interesting approach to ease the types of problems just discussed is seen in the CALCHEM project in Britain, a chemistry project based primarily at Leeds University. Although most of the dialogs are written in two or three locations, about a dozen faculty from other institutions are involved in the committee running the project as a whole. Hence, chemists from many schools feel they have some stake in the output. This tactic should ease the transferability to these new sites.

Much work needs to be done here, much of it not particularly unique to the computer situation. We need to study in more detail the factors which inhibit the transfer of successful innovative learning ideas of all types, including those associated with computers.

Long-range Computer Aspects

When we change the focus from short-range to long-range aspects, the problems and prospects become entirely different. Past discussions have often ignored these long-range aspects. But from the standpoint of eventual use of computers in many different learning situations, they are by far the most important. So the developer of such products should be very concerned with these long-range aspects.

Here we need to look at some hardware/software futures for computers, because that affects what is possible. Undoubtedly the most important feature of modern computer technology is the very rapid current development; computers are becoming more powerful and less expensive. An important aspect is the rise of LSI and related technologies, including new memory techniques. These developments suggest very different computer systems for the future than current ones. All of our existing learning materials, we can safely say, are running on already obsolete machines. From this point of view the question of transferring materials immediately to machine X becomes then less important, particularly for the developer of computer-based learning materials who looks to the future.

At least two different hardware futures for computers are being projected at the moment. One involves larger and larger networks so that more and more terminals are accessing the same CPU or a group of CPUs. Donald Bitzer, Director of the PLATO project, has been suggesting recently the construction of a million terminal netowrk, with 200 interconnected CPUs and communication supported by satellites. The present ARPA net, and some of its commercial offshoots, furnish another example of such possible networking.

A second future possibility gives an entirely different view of the computer universe, one that is dominated by the evolving microprocessor (and its later descendents) built into all devices. Today's terminal would be tomorrow's computer. Such stand-alone systems could function by themselves, with full computing capabilities, without connection to a large central computer, although they might occasionally connect to another computer for such specialized purposes as massive calculations or accessing a rapidly changing centralized database. As these systems would function primarily stand-alone, they would not be limited to current communication speeds and so could do things such as full animation which are impossible in a communication-limited environment. Other aspects of modern technology, such as the home videodisc system, might become important components of such systems.

We do need to worry about effective delivery systems that allow us to carry out all the functions that a modern teaching system will need. Such a system should have full multimedia capability, color, high speed graphics, and at least audio output capability.

No matter which future we look at, one fact is clear; future systems will cost much less than current systems cost. Projections indicate that, because of our increasing capabilities with computer technology, computer costs will continue to decline over a long period of time. Hence, we can expect the computer systems of the future, for education and otherwise, to be cheaper and cheaper.

This leads me then to Bork's Second Rule:

WHEN WE CONSIDER THE LONG-RANGE POINT OF VIEW, <u>NO</u> COMPUTER ASPECTS OF TRANSFERABILITY ARE IMPORTANT.

That is the technology itself, with its ever-increasing effectiveness, will obviate the problems of transferability. If the massive networking system happens, then of course the programs will be available on any one of the million terminals. If stand-alone systems become extremely widespread and dominant, much more so than current computers, the materials can be written for such widely available systems. Furthermore, the possibilities of microprogrammability and inexpensive CPUs mean that even code written for different machines may be able to run on a variety of machines. A single machine could have CPUs matching the institution's sets of different computers or could emulate in microcode a wide variety of machines.

As materials are improved, and thus in greater national demand, stronger emphasis will be directed towards making them more available. Hence, marketing of computer-based materials will also aid in solving problems of long range transportability.

So the massive problems of transferability which appear with regard to the technical aspects when we examine the short-range all vanish in the long-range. From a long-range point of view we do not need to put large efforts in this direction except to insure the type of hardware that will make the transferability possible.

A corollary, based on the first "rule," is that many things prepared with short-range computer transferability in mind will seem too restricted to survive far into the future. Only the best current materials, using as wide a range of capabilities as possible, are likely to be usable in the distant future.

Long-range Innovative Learning Aspects

To my mind this category presents some of the most interesting problems. Unlike some of the other categories, it is not entirely independent of what has gone before. Some of the techniques involved in dealing with short-range teaching aspects also will be useful in dealing with the more long-range ones, particularly those which involve the political and sociological problems of widespread computer use.

The question of how these future materials should be marketed is very important. As already indicated, most current materials are produced in a "cottage industry" format We need to develop much more careful production and marketing facilities, including the provision of royalties as an incentive to authors. It will be expected that commercial distribution methods will be vital, just as they are for books and other learning materials.

Any consideration of this aspect needs to worry also about the development of new types of course, ones made possible by the existonce of the computer. It also needs to consider new modes of education, where the formal school is replaced by other mechanisms such as the Open University in Britain or through extensions in the public libraries or homes.

From the long-range point of view we can expect the computer will not be a passive teaching device, but will contribute to a vital restructuring of our educational system.