Computer games for the teaching of reading

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The development and implementation of programs of computer-based instruction for reading are discussed.

Cheap computer power abounds now, and we all have the urge to use the computer for all sorts of tasks that have previously been difficult to accomplish. Further, we are challenged intellectually by the problem of using the computer for instruction. The remarks below focus on a specific aspect of that challenge, the use of computer-based instruction for reading. First, I suggest an informed, research-driven approach to selecting topics for computer-based reading instruction. Second, I discuss several issues of man-machine interaction that are particularly appropriate in building programs for people who do not read well. After that, I briefly address the issue of adapting to individual style differences. I conclude with a brief discussion of some specific possibilities for reading games and of the suitability of existing hardware for reading instruction.

WHAT SHOULD WE BE DOING?

What is the appropriate use for the computer in teaching reading? When we ask ourselves this question, we see an immediate conflict between what is challenging and fun to do and what would be most helpful in the classroom. It would be a real challenge to build complex comprehension tutors that engage in unconstrained dialogues with students. The possibility of an electronic Oxford don for every poor, underprivileged child is really exciting. However, the needs of children and the equipment available for the next few years suggest that we take on a task that is boring as a computer science exercise, but more likely to make a major difference in the classroom.

First, there is considerable evidence that children who are slow in responding to words will be low achievers in reading. There is no experimental evidence that practice in processing words, subwords, or phrases quickly will lead to better reading, but there is enough causal modeling data to justify training study efforts. Perhaps the most economical approach to such training studies is the computer. Games that emphasize word processing speed or efficiency will be relatively easy to produce and can reasonably be expected to improve reading skill.

Second, vocabulary enhancement can be added to simple word processing games. There is specific training study evidence (Beck, Perfetti, & McKeown, in press) that shows the efficacy of intense vocabulary enrichment

activities, including speeded tasks as well as tasks that build more elaborated meaning knowledge. Beck et al.'s training study showed differential effects for differential amounts of exposure to training on specific words and a general effect of the training on subsequent reading achievement tests. Words and word meaning and speed of processing are the places to start, I believe. We can then advance to tasks that emphasize systematic attention to the component subprocesses of comprehension, and even tasks that concentrate on building efficiency of higher level comprehension skills.

HUMAN ENGINEERING

Having selected a domain for computer-based instruction efforts, we should give some thought to the problems of interfacing poor readers with the computer. The personal microcomputers that are the most affordable and popular for school use are poorly suited for maintaining any kind of complex dialogue with children of low reading skill. Some have no lowercase letters; almost all have poor screen resolution and can display only a small number of relatively short lines at a time. This is not a problem for some instructional activities, but it is hard to imagine improving word recognition efficiency with a system that does not display words very well, and some personal machines do not.

A second, more severe, problem involves communication from the child to the computer. Those who read poorly tend not to be able to type too well either. When lack of typing ability is combined with lack of reading facility, typing input can become very painful. We need to search for alternatives.

The key to successful input is to have the child respond by selecting from menus whenever possible. A choice can be indicated by several means. First, it is possible to have a touch-sensitive screen that inputs to the computer the coordinates of any contact of the child's hand with the screen. When combined with a "map" of the location of displays on the screen, such an input is sufficient to indicate the child's choice. Touch screens can be made using either arrays of photo-cells and detectors along the sides of the screen or special material with embedded conductors that, when combined with appropriate interfacing electronics, give extremely precise touch-location information to the

computer. The costs are between \$300 and \$1,000 at the moment, depending on specifics of resolution and method used. Spatial input can also be given by devices such as joysticks or "mouses." (A "mouse" is a hand-held device that conveys direction by being moved on a tabletop. Thus, pushing the mouse to the left becomes an instruction to move the cursor to the left, pushing toward the screen means move the cursor up, and so on. Both of these devices allow the child to input information about the direction that he would like a cursor to move on the screen.

A less expensive approach is to use a small number of keys for menu selection. In the new Apple LOGO, for example, there is a rich set of commands for moving a "turtle" around on the video screen by telling it to turn in a particular direction and to go forward specific distances. A demonstration program sets up the F key to produce a small forward movement and the T key to produce a small turn (30 deg). Thus, with only the F and T keys, the turtle can be moved to any point on the screen. The potential for such a system as a means of student input is substantial. An alternative that involves no graphics is to present a set of alternatives on the screen and then position the cursor near the first choice. In this system, pressing the Y key selects the currently indicated choice and pressing the N key causes the indicator to move on to the next choice.

For computer conversation with the child, voice output should be considered. This is a rapidly changing field, and the best is yet to come. Nonetheless, even today it is possible to develop allophonically coded speech that is moderately intelligible, using the VOTRAX integrated circuit. The cost per unit for added voice is likely to be a few hundred dollars. With perhaps \$1,500 for a development system that has greater flexibility, one has the basis for refining and tuning the speech encodings to make them more intelligible. VOTRAX systems have the capability of contouring pitch, intensity, and speed of speech, but they do not yet have intelligent support for doing this automatically. Today, in order to use allophonically coded speech, you have to do your own painstaking fine tuning. However, support systems for doing this are being developed, and intelligent tailoring systems are likely to be available in several years.

ADAPTING TO INDIVIDUAL DIFFERENCES

In the past, adaptive instruction has often meant merely changing the rate at which new material is presented and changing the amount of extra drill that is provided. With a new instructional medium, we have new needs to address. After all, not every child will think that playing a particular game designed to provide reading practice is fun. Some might prefer games on different topics. Even more important, teachers and parents will have serious reservations about having children

playing games instead of engaging in character-building suffering. Any instructional systems that we develop, especially those that look a lot like arcade games, will need intelligent components that can observe and answer questions about the child's interaction with the system.

For the parent, such an intelligent component should be able to describe what the child did when he played the game, which skills it was designed to improve, and what evidence from the child's playing of the game shows whether improvement did or did not occur. The teacher will want similar information, perhaps in a different form or with different vocabulary. The system developer will want a built-in "research assistant" that can gather the information necessary to evaluate and refine instructional software.

All of these capabilities are within the state of the art, in that they are, in their less pretentious forms, routine applications of artificial intelligence programming techniques. However, they will require a language better than BASIC (probably LISP or an enhancement of SMALLTALK), more memory, and faster processors than are found on today's 8-bit personal machines. They are quite within the range of the 16-bit systems now starting to appear.

EXPLORATIONS IN PROGRESS

We are currently exploring three possibilities for computer-based reading instruction. First, we are building a variety of beat-the-clock formats (Isabel Beck is doing the design work) that allow children to compete with their own prior times and with more external criteria in such tasks as synthetic phonics, decision making about the meanings of words, and so on. With appropriate scoreboarding and using a touch screen, games that provide lots of opportunities for drilling word recognition can be developed.

A second avenue is to use the shell of games like "Adventure," which are very explicit, simplified, finite-state machines (Collins' group at Bolt, Beranek, and Newman is also using this approach). At each state, the child is shown some text and has a limited range of options. The option the child specifies determines the next state entered. Scoring depends upon which states the child passes through and which responses he or she makes. Clearly, the texts presented and the responses permitted can be chosen to facilitate exposure to certain comprehension situations. Also, it is possible to have games that are equivalent in the practice opportunities they provide but totally different in the fantasies they support.

A third technique is the "reading machine." By this, I mean a device that presents text in an environment in which certain "assists" are available. For example, perhaps the machine could pronounce any word the child touched, allowing the child to continue understanding

text even if he is tripped up by a word or two. On-line dictionary assistance and perhaps even on-line explanatory aids relating to the story are other possibilities.

SUMMARY

There are many useful things we can do with the computer for reading. We need to remember that what is challenging may not always be what is needed. We also need to learn to think like architects, building from

basic general forms to suit the specific needs of individuals. The trick is to match easily realizable forms with effective function—But that is what design is about.

REFERENCE

BECK, I. L., PERFETTI, C. A., & McKEOWN, M. G. The effects of long-term vocabulary instruction on lexical access and reading comprehension. *Journal of Educational Psychology*, in press.