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How Can We Aid the Learning of Young Children with Computers

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Early Learning

A very important part of the learning process occurs during early childhood, before preschool and the first few grades. The child since birth has, in almost all cases, successfully learned a language and a simple theory of the universe around her or him. This wonderful learning is done without schools and teachers. Children are eager learners, exploring the world with all their senses. This informal learning period, for most people, is the most successful period of learning in their entire life.

A recent review from the National Academies gives many details of contemporary research in this area: *From neurons to neighborhoods: The science of early child development* (Shonkoff & Phillips, 2000).

Many do not learn as well in later life. We need to try to understand the characteristics of this early learning, and ask if they can be extended to later education. While our concern here is with computers, the results of such a study might also tell us much about other aspects of learning.

While the following list not complete, it shows some critical factors:

Some Aspects of Young Learning

In thinking about how to use computers with young children, we need to think about this successful and satisfying early learning. What are the characteristics of this informal learning? Several features are important. The reader may be able to suggest more.

- The young child interacts frequently with the world, both the world of people and the world of objects. Watching a child at play illustrates this high level of interaction. All the senses come into play in this activity, sight, sound, touch, and taste.

- Language is increasingly important in this interaction as the child grows. Learning a language is the major endeavor of the "student" in early years. After that, almost all children love to talk, both to other children and to adults. This becomes one of the major activities of the child.

- The child learns alone or in very small groups. Learning is seldom a class size group activity in these early years.

- Children are highly motivated to learn. Learning is their major activity. They love to learn.

- Each child learns at a unique rate. There are no standards or grades in this early learning.

- The child almost always succeeds in learning.

Next, we examine present computer learning modules for young children in the light of these factors.

Existing Computer Material

When we examine the available computer learning modules for children, we find few of the characteristics just mentioned. They tend to be dominated by

entertainment, rather than concerns for learning. Cartoons, puppets, loud music, and "themes" such as magic horses are common. Student interaction is almost always by pointing, a form of interaction seldom used in previous learning. The human voice is used only by the computer, not the student. Some modules encourage problem solving, but many do not.

Learning for the young child quickly moves to the classroom environment, where we can no longer treat each child as an individual, but must resort to group practices. Many people have argued that the fixed pace classroom is not the best place for young children to learn. Montessori is one such example.

Why does the currently available computer-based learning material for young children depart from what we know about their learning? This material is often produced by groups who are unfamiliar with the research in the learning of young children. There is a belief that computer materials cannot have the characteristics previously noted; or that such material can be produced, but are too expensive for practical use. There is also a strong tendency to imitate learning as it occurs in the classroom.

We argue in this article, and more extensively in the references (all references by Bork), that these reasons are not reasonable. We *can* practically produce computer-learning material that closely follows the learning style of the young child.

Highly Interactive Learning Modules

The model or paradigm for the type of learning units proposed is that seen in the interaction between a skilled tutor and the individual student. In this type of interaction the responses are frequent, and the quality of each interaction is high. The typical interaction is one in which the tutor asks the student a question and the student responds. Both the question and the answer are in the student's native language. Responses are free-form not multiple-choice. The tutor's next question is based on the response, and on previous experiences with the student.

It is the tutor's job to ask the right questions to discover the child's weaknesses, offer the appropriate assistance to the child, and to evaluate if

this help was effective. Learning is individualized. Each tutored child moves at a unique pace. Note how different this is from what happens in the typical classroom. The classroom cannot have such an active level of participation by all students, nor a unique pace for each, because of class size, except in the case of an extremely skilled teacher.

While this type of learning is often very successful with skilled tutors, it is too expensive to consider it as a general mode of learning. However, we can now achieve the equivalent results with the computer as the tutor, using carefully programmed highly interactive learning modules. The program can store and use information about student performance and problems. We would not claim that the computer could compete with a very skilled tutor, but rather that tutorial, computer-based learning can compete very well by helping students learn in the typical classroom situation.

The critical question in tutorial, computer-based learning units, is what learning material should next be presented to the student. This must be done on a moment-by-moment basis within the computer program. The concept is similar to Vygotsky's zone of proximal development (ZPD). To understand what the student is ready to learn next, we must use information from what has happened previously, and from recent student responses. We must have an understanding of what the current student problems are. With this information and the proper design, the learning program can make the appropriate decisions.

As already suggested, the critical factor to be considered is the level of interaction. Our studies in libraries, show that to maintain the student interest in "free" environments, such as in distance learning, we must maintain a learning interaction level of twenty seconds or less between interactions. This level is seldom seen in classrooms or distance learning material. I stress the typical interaction is a question from the computer, in the student's native language, and a free-form student response.

In the future it is likely that the student input will be by voice. Typing will probably no longer be needed except for those already addicted to it. Current commercial speech recognition is adequate in many languages.

Developing Highly Interactive Learning Modules

Current typical strategies for developing computer-based learning material are inadequate to the kind of material we now need. We have been developing such material at the University of California, Irvine, for over 30 years. Therefore, we have a well-developed system for producing highly interactive tutorial computer-based learning material. The system includes a methodology and software, and is well described in the literature. The reader might be particularly interested in Chapter 11 in a new book describing this strategy, *Tutorial Distance Learning—Rebuilding Our Educational System* (Bork & Gunnarsdottir, 2001).

The key individuals in this development are skilled teachers who design the modules, and work regularly with individual students. These teachers are aware of the potential problems for students, and have ideas about how to help them with these problems. We find it best if they work together fulltime in groups of about four. Typically the group stays together for a week. The first morning is used to stress the approach needed for creating highly interactive modules.

We provide a mechanism for reporting all the decisions made by the group of designers. We call this document a script. A script contains, in visual form, all the information about how the program is to behave. This includes the messages that the students will receive, text and voice, the analysis of student input, and the decisions about what is presented next based on this input. The script also includes information about what is to be stored, and how it is to be used.

In our early activities the scripts were on paper. Today, though that is still possible, authors can enter the script directly in the computer. Much of the code can be written directly from the computer-stored script. Based on later experience, such as from the evaluation, this script can be changed many times.

No matter how competent the designers are, it is necessary to evaluate the material with students, and make modifications based on this evaluation. Two cycles of improvement and evaluation are desirable. Much of the data needed can be stored by the computer. Evaluation of large numbers of students with widely different backgrounds is important.

Next, consider some possibilities for early childhood learning.

Some Interesting Possibilities for Development for Young Children

We now consider some future interactive computer-based learning projects that help young children. These developments will follow the characteristics described. All are practical today, and there are proposals for each of them, in varying degrees of completeness.

Reading and writing. A very important early activity of the child is learning the important arts of reading and writing. In natural order, these follow speaking. The teaching of reading in the United States goes through cycles. In some periods we teach reading by a whole language method and in the others by a phonic method. Both are probably needed given the wide variety of students. No matter which we use we have a large number of adult illiterates in United States. I believe this is intolerable in a democratic country. We should be sure that everyone can read.

With tutorial computer material we have a new strategy that may be useful. Of particular importance in this learning material is likely to be the use of voice for student input, and the ability of the computer to speak clearly. While writing is not often taught at the elementary level, it can be an important companion to reading when the two are taught in parallel.

Many strategies are possible. The designers (skilled teachers of reading and writing, as described in the previous section) would develop them. A possible beginning for such a program would be for the computer to say "tell me a story." If nothing happens in a short time, the computer may prompt the student. When the student begins to talk, the story appears on the screen. Speech, already known to the child, is related to text, important for both reading and writing.

Scientific literacy. We live in a world where science affects many aspects of everyday life. However, most people have little understanding of how the scientist gathers knowledge, or of the nature of scientific knowledge. This is a problem in the United States, and in the world.

With tutorial learning material we can place students in an environment where they work like scientists. They can conduct online experiments, develop theories based on these activities, and test the predictions made by the theory. In programs we developed fifteen years ago, students created such theories as Mendelian genetics. As with tutorial material generally, all students succeed—there are no failures.

A full learning program must cover many areas. This is a good place, we believe, to conduct a major experiment in the effectiveness of tutorial learning with computers. The results of this experiment would be critical in planning future developments. A detailed proposal for such an experiment based on scientific literacy is available.

Mathematical literacy. Another possibility would be mathematical literacy. This could also be combined as a joint activity with scientific literacy.

Electronic headstart—preschool. The Headstart program in the United States was aimed at students of low socio-economic backgrounds, to prepare them for school. It was considered successful, but the costs are too great for general use.

Although it is the most speculative of the projects mentioned here, a computer-based Headstart program has good possibilities for success. Again voice recognition is critical, as these children cannot read.

CONCLUSIONS

The prospects for the future with this new type of learning are good. We need a major international experiment to verify this, and to plan for future development. Starting with young children is a reasonable choice.

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