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ABSTRACT

Computer-based learning environments are proliferating in an effort to make more resources available to more students in more timely and individualized ways without overtaxing diminishing budgets. Many computer-based learning environments are designed to facilitate meaningful interaction, however, interactivity is only one of the factors that distinguishes the medium-based learning experience from a direct learning experience. The assumption in computer-based learning environments is that the understanding gained will transfer to situations in which the knowledge will be used. A study was conducted to determine if students learning from a physical, wooden abacus would be able to perform better (faster and more accurately) than students learning from a computer- simulation of an abacus. Third graders from public schools were divided into four groups and tested on interacting with a physical abacus, interacting with a computer simulation of an abacus, watching a physical abacus, and watching a computer simulation of an abacus. After instruction and practice, students were tested on their ability to use a physical abacus. Recognition test results were the same for the two groups (physical abacus versus computer simulation). The students who learned on the wooden abacus had an advantage in time and accuracy over the students who learned from the computer simulation. When asked to extrapolate what they had learned to a more advanced domain (adding), the students who learned on the wooden abacus had a more solid foundation for this than those who learned on the computer simulation. (Contains 16 references.) (SWC)

Learning from a Computer Simulation
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Unintended Results of Using Instructional Media, Part II: Learning from a Computer Simulation

Background

Computer-based learning environments are proliferating in an admirable effort to make more resources available to more students in more timely and individualized ways without overtaxing diminishing budgets. These learning environments vary widely in the technology they use, the interactivity involved and the degree of meaningful context that's available. Thus, as Kozma pointed out (Kozma, 1991), the computer-based learning environment is not defined by any single, critical, factor. Nevertheless it sets up a learning environment that as a whole facilitates some aspects of learning while possibly hindering others. It seems fairly well established that experience with good computer-based learning environments can help students acquire substantial knowledge, and even mental models, especially when that learning environment provides some opportunity for interaction(Alessi & Trollip, 1985; Papert, 1980; Salomon, 1990). The assumption implicit in even the best of these computer-based learning environments, however, is that the understanding gained will transfer to situations in which the knowledge must be used. While this certainly may be true, the assumption needs to be examined empirically. It is from this perspective that we have examined the effect of computer-based learning, specifically of an interactive computer simulation similar to one that might be incorporated into an elementary curriculum.

Hypothesis

We tested the hypothesis that students learning from a physical, wooden abacus would be able to perform better (faster and more accurately) than students learning from a computer-simulation of an abacus on production tests of studied items, non-studied items and on a far transfer task. We hypothesized that there would be no difference among these groups on a recognition test.

Method

We worked with 60 third graders from public schools in rural and suburban New York state (28 boys, 32 girls, mean age=8.95 years). We met with two students at a time for about an hour. Each pair learned how to represent numbers on an abacus. The instruction was the same for all pairs, although half the pairs learned how to represent numbers on a physical, wooden abacus and half the pairs learned how to represent numbers on a computer simulation of an abacus. Following the instruction, the students had time to practice what they had learned. Within each pair one of the students was randomly assigned to interact with the abacus (or simulation) and the other was assigned to learn what they could from watching. Pilot studies had lead us to believe that interaction vs. noninteraction was an important aspect of working with instructional media (Flanagan, 1996; Flanagan & Black, 1993; Flanagan & Black, In press). This gave us a total of four conditions: interacting with a physical abacus, interacting with a computer simulation of an

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abacus, watching a physical abacus, and watching a computer simulation of an abacus.

Following the practice period the students were tested on their ability to use a physical abacus. They were not tested on their ability to use the computer abacus, because the question being examined is whether anything is lost when a computer acts as an intermediary between a learner and the device to be learned. When the device to be learned is a computer system we can no longer call that learning environment a simulation, since it provides a direct experience of the device to be learned. Three tests, one on recognition knowledge, and two on performance (or production knowledge) and one far transfer task provided the main measures in this study. The two performance measures required the students to represent numbers on the abacus as accurately and as quickly as they could. The first performance measure tested their ability to represent numbers within the range in which they had learned and practiced (1 - 30). The second measure tested their ability to represent numbers beyond the range in which they had learned and practiced (30 - 250). The recognition test required the students to read an abacus and write down the number being represented. All the numbers on this test were within the studied range. For the far transfer task the students were asked to "make a guess" (since this was not taught) how to use the abacus for adding two numbers. The students were categorized into three groups based on their responses: those who understood how to add with the abacus spontaneously (spontaneous adders), those who understood how to add after prompting from the researcher (prompted adders), and those who didn't understand how to add using the abacus even after prompting (non-adders). Following these measures the students were interviewed for information regarding age, opinion of the experimental tasks, and how much they are exposed to media (instructional and otherwise) on a regular basis.

Results

An analysis of variance was performed by pair of students, with two within-pair factors (doer vs. watcher and studied vs. new test item) and one between-pairs factor (wooden abacus vs. computer simulation). Contrary to hypothesis these data did not show any difference between the children who interacted with the device and those who learned by watching (doer vs. watcher). This result is both counter-intuitive and contrary to previous results (Flanagan, 1996; Flanagan & Black, 1993; Flanagan & Black, In press). Although this could be partially attributed to the Hawthorne effect - all the children performing better than usual because of increased personal attention - it is not a very satisfying, nor a complete explanation and deserves further investigation. However, the distinction will not be discussed further in these results. As predicted, there was no difference between pairs who used the wooden abacus and the pairs who used the computer simulation on the recognition test ($F_{(1,28)}=.119$, $p>.75$). There was, however, a significant difference between these groups on the production tests in terms of proportion correct ($F_{(1,28)}=12.36$, $p<.005$), and time spent ($F_{(1,28)}= 4.77$, $p<.05$). Finally, there was a significant asymmetry in the distribution of spontaneous adders, prompted adders, and non-adders over the "medium" factor such that there were significantly more prompted adders and fewer non-adders among those who used the wooden abacus rather than the computer simulation of an abacus (Likelihood ratio of 9.19 with 2 d.f., $p=.01$).

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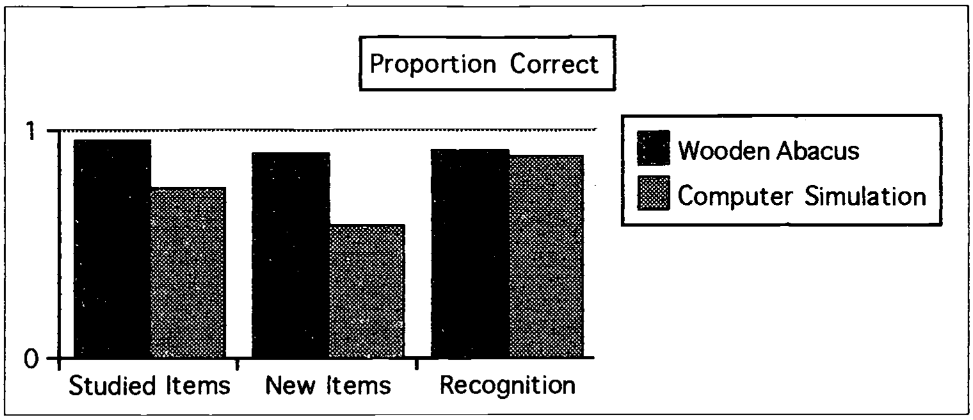

Figure 1: Proportion Correct of Production (New and Studied) and Recognition Items

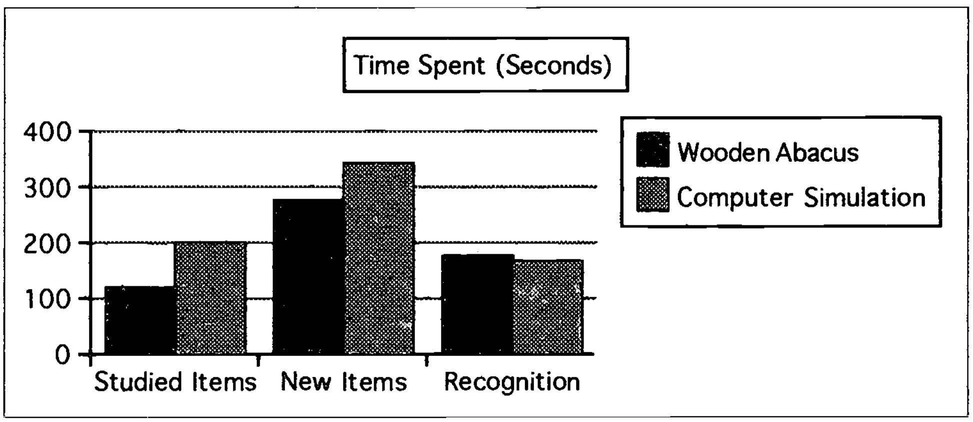

Figure 2: Time Spent on Production (New and Studied) and Recognition Items

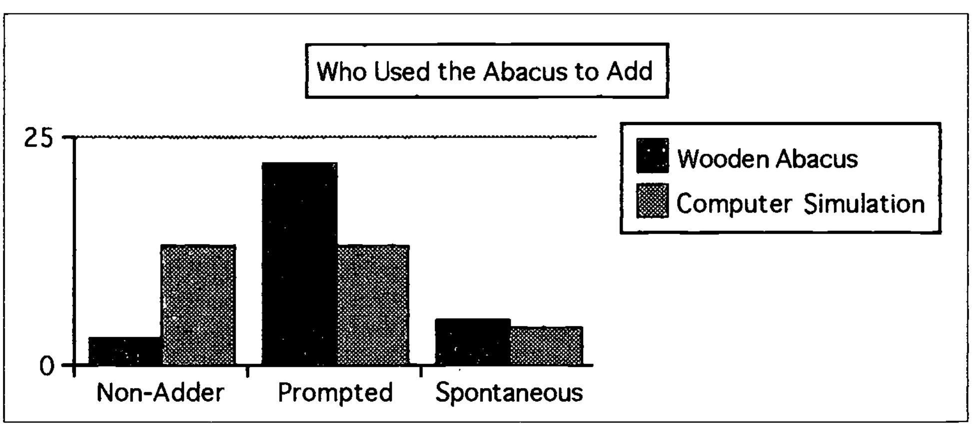

Figure 3: Ability to Use Abacus to Add by Medium Used for Learning

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Discussion

Educators have long recognized the need to engage students with interactive tasks ((Anderson, 1980; James, 1890), for example). Many computer-based learning environments are designed to facilitate meaningful interaction (Ambron & Hooper, 1988; Daiute, 1985; Flanagan & Piccolini, 1992; Harel & Papert, 1991; Papert, 1993; Robertson, Zachary & Black, 1990; Scardamalia & Bereiter, 1991), and this is encouraging. However, interactivity is only one of the factors that distinguishes the medium-based learning experience from a direct learning experience. This study examined a second factor: the physicality of the device being learned. Following instruction and practice, students from both groups were able to understand the way numbers are represented on the abacus, as indicated in the recognition test results. However, in production tests, in which the students had to use an abacus themselves to produce studied and new numbers, the students who learned on the wooden abacus had an advantage in time and accuracy over the students who learned from the computer simulation of an abacus. Furthermore, when asked to extrapolate what they had learned to a more advanced domain (adding), there is some indication that the students who learned on the wooden abacus had a more solid foundation for this than the students who learned from the computer simulation. In summary, while computer-based learning environments are clearly sufficient for some types of learning, careful examination of the particular types of learning that result from a computer-based learning environment seem to be indicated by these data.

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