# MATHEMATICS, COMPUTERS AND "AT-RISK" PRESCHOOLERS


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This paper summarises our earlier research in the field of computers and young children, presents data and analyses from our current research, particularly in the context of mathematics education, and discusses possible future directions for this research.

## BACKGROUND

Our work with computers and preschool children dates from an Australian Apple Education Foundation grant awarded in 1984. About this time, we produced a number of papers focussing on the role of computer-based activities in early learning (Elliott, 1985; Hall, 1984, 1985; Hall and Elliott, 1985). At that time there was little research data available as to how to use computers with very young children.

Our first empirical research was exploratory in nature, and addressed questions relating to young children's learning through computers, and the nature of young learners' interactions with computers and peers. A large quantity of data was gathered, partly about young children using mathematics and pre-mathematics software, but also on a wider number of variables such as the frequency with which children used the computer, how long they stayed at the computer, how they used and interacted with the robot attached to the computer, the language used while at the computer, and the extent of independent, parallel and cooperative play (Elliott and Hall, 1985a, 1985b, 1986a, 1986b; Hall and Elliott, 1986). Some of the findings from this research are presented here in Tables 1 and 2.

One of the early concerns of preschool teachers about computer access for young children was that it would become a socially isolating experience. That is, there were preconceived notions that a child would work alone at the computer, and so spend part of the day in isolation. Our data indicated quite the opposite: we had many observations of social interaction, of emerging leadership skills and of cooperative behaviour.

**Table 1:** Social interaction and cooperative behaviour*

| | Total | Mean |
|---|---|---|
| Children observed in computer area | 190 | 3.3 |
| Children observed interacting socially in computer area | 148 | 2.6 |

* data based on 57 observations

The data in Table 1 illustrate some of our findings: typically there were three children at the computer, and typically they were interacting socially and working cooperatively.

**Table 2:** Sex differences in computer usage

| | |
|---|---|
| Average number of girls in computer area at any given time | 1.2 (10%) |
| Average number of boys in computer area at any given time | 2.2 (24%) |
| Average time on task - girls | 8.2 minutes |
| - boys | 18.8 minutes |

Data from Table 2 show that in this group of children there are clear sex differences in the number of boys and girls at the computer at any given time, and there are differences between boys and girls in the time they remain working in the computer area. More boys came to the computer than girls, and they remained longer.

More recently we decided to use as our subjects those preschoolers considered to be 'at-risk'. Typically this meant children who were as 'average' in all respects as other children except they were in community and home settings where there was a constant high level of stress, which often led to slower physical, social and academic development. Further, we selected mathematics to be the discipline because it is an important and neglected area in preschools, and because these children's mathematical skills and understandings were likely to be below that of their peers in other preschools. Another consideration in choosing mathematics was our view that teachers and other care givers in early childhood settings frequently lack confidence in mathematics: we saw the computer as giving these people support and a structure in which to encourage young children's mathematical learning. In this research we established that 'at-risk' children, working in pairs at a computer together with an adult, and using commercially available mathematical software, were able to make significant gains in a range of mathematical skills (Elliott and Hall, 1990a, 1990b, 1990c).

Data were collected from two groups of children who worked at a computer in pairs with adult assistance. Children spent twenty-minute sessions at the computer, and totalled two to four hours in all over the six weeks of the research program. The control group used a range of non-mathematical software, the experimental group used commercially available mathematics software designed for young children. In each case the adult supported children in their learning, gave assistance when necessary, and encouraged children to remain on task. Table 3 shows some of the findings from this research with 'at-risk' preschoolers.

**Table 3:** 'At-risk' preschoolers pretest and posttest scores

| | Pretest (maximum score is 80) | Posttest |
|---|---|---|
| Control group (n = 4) | 47.5 | 43.0 |
| Experimental group (n = 6) | 46.5 | 65.2 |

Parents and other care givers frequently do not expect these children to 'learn': they have low expectations of these children in terms of academic achievement. So even though a Wilcoxon two sample test showed the gains made by the experimental group to be significant at the 2% level, from a more general educational perspective an equally significant finding is simply that some mathematical learning did indeed take place.

## THE PRESENT RESEARCH

Our original research with preschoolers and computers had as its theoretical base children's social and cognitive development, and we gave more emphasis to the cognitive aspect as we moved from project to project. In trying to further our theoretical base we looked firstly to Information Processing Theory. Information Processing Theory may be seen as a process where sensors receive data which are transferred to short term memory, and may then be called from or sent to long term memory. Directing the processing of data in short term memory, and its flow in and out of long term memory is a control mechanism. This control mechanism varies considerably between people, and between contexts. An individual's awareness and ability to manipulate this control function consciously is referred to as *metacognition*. Its importance lies in the increasingly accepted view that high levels of metacognitive awareness are associated with high levels of performance on a range of cognitive tasks. Applying this to our own research raises questions such as 'can adult intervention as young children use mathematical software at computers lead to increases in children's metacognitive awareness?' and 'will this result in higher levels of mathematical achievement?'. This theoretical position is not as well developed as the one described below.

A second theoretical base for the present research derives from Vygotskian notions of the zone of proximal development and the internalisation of externally provided guidance. According to this perspective early learning is mediated by interactions with competent others (Rogoff, 1990; Vygotsky, 1978) resulting in ongoing stimulation and motivation for learning, as well as support of a more metacognitive (or self-regulatory) nature. A key function of self-regulatory behaviour is its role in helping children become active participants and controllers of their own learning (Zimmerman, 1990).

From this perspective the value of using a computer to generate worthwhile learning experiences lies in the prestructured content and in-built cognitive supports of its software (for example, feedback, memory aids, sequencing, and the predictable and predetermined flow of a computer-based activity), as well as its highly motivating and engaging nature. When these contextual features are supported by co-participants (teachers and peers) the result should be increased cognitive activity. Complementary peer interaction, as well as the individual's own structuring of the activity, results in cognitive and metacognitive dialogues that serve to support and mirror knowledge and thinking.

## METHODOLOGY

Our latest research concerns three groups of randomly selected 'at-risk' preschool children, two groups working in pairs at a computer with adult assistance and a control group. Each group was given a pretest, and four weeks later a posttest, using the TEMA 2 instrument. Children in the experimental groups received about fifteen twenty-minute computer sessions over a four week period, the control group children had no computer sessions, and all children took part in the usual day to day activities of their preschools.

An essential element of this research is the role of the adult. For one experimental group the adult took on the role used in the previous research: that of a caring and supportive guide. The adult encouraged children to remain on task, and provided reinforcement. For the second experimental group the adult adopted what we refer to as 'a metacognitive approach' to teaching. In this approach the adult went beyond the caring and supporting role so that as the child was asked a question through the computer and answered it, the adult extended the activity by giving explanations and additional instructions, and by asking the child a range of questions. The adult gave direct guidance, provided cues and questions, and modelled and demonstrated aspects of the material to be learned. These approaches are described more fully in Elliott (1991). The interactions between adult and children were intended as the link between existing and new knowledge. The computer software focusses the child on new learning, the adult's interventions have learners link this new knowledge with their present knowledge. The adults intervention is essential in ensuring there is a 'metacognitive' aspect to the computer sessions. The adult's directions and questions typically took the form of 'show me three fingers', 'clap three times', 'count my (three) fingers', 'let's count these together', 'draw a three in the air with your finger', 'what song did we sing yesterday that had three in it?', 'tell me about the story we read earlier today where there were three kittens', and 'write a three for me'. Data were gathered during 1991, with some follow up data in 1992. These data are still being analysed, with some results outlined below, and a report is in preparation (Elliott and Hall, 1992).

## RESULTS

Data from this research are still being analysed, but early indications are that both teaching approaches provide greater mathematical learning than the mathematical content of the preschool's existing program. There is support too to show that a metacognitive teaching approach will result in greater mathematical learning than a typical caring, concerned teaching approach. That is, there is a specific teaching approach that encourages learning of mathematical concepts and skills, and it is a better approach than would typically be used by teachers in preschools. Some results are displayed in Tables 4 and 5. Other indications are that children work effectively in pairs, that the computer provides strong motivation for most children, and that the adult and the computer create an environment that keeps children's learning focussed.

**Table 4:** Metacognitive, caring and control groups: pretest versus posttest scores (one tailed t-test)

| Group | Raw scores | Percentile scores |
|---|---|---|
| Metacognitive (n = 18) | .0001 | .0001 |
| Caring, supportive (n = 17) | .0001 | .0001 |
| Control (n = 19) | n.s.* | n.s.* |

* not significant

**Table 5:** Metacognitive versus caring groups: pretest and posttest scores (one tailed t-test)

| Pretest scores | | Posttest scores | |
|---|---|---|---|
| Raw | Percentile | Raw | Percentile |
| n.s. | n.s. | .0527 | .0456* |

* significant at .05 level

## DISCUSSION

Further work in this area will be concerned with the role of metacognitive processes in early mathematics learning, the teaching of mathematics in preschools, the role of the computer in this process, and the professional development of early childhood teachers. For example, one of the authors is presently working on a curriculum development activity involving 'at-risk' preschoolers learning mathematics through computers, and we intend to develop a teacher's kit to be used in professional development activities. Some data and resources are presently available for this, but extra funding will be sought shortly.

In research terms, further work needs to be completed:

(a) in refining the metacognitive model we are using. In particular which contextual supports seem most effective in maximising metacognitive activity and academic competence?

(b) in contrasting learning through an intensive program such as our 1991 work, with regular computer sessions throughout the year;

(c) in examining the impact of this experience on these children's first years of school;

(d) on the professional development of trained and untrained teachers;

(e) on the appropriate content of preschool mathematics programs for these children; and

(f) on the specifications of computer software for these children.

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