Infusing ICT Use within the Early Years of Elementary Education

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Abstract

Despite the ubiquitousness of computers in pre-schools and primary schools, there exists both confusion and contradiction concerning ICT and young children. The paper commences with brief reviews of some early years curriculum statements, position papers and selected research from around the world. There is a considerable body of research reporting educational advantages that arise from young children using ICT in a variety of learning situations. There are also reports from both government and independent bodies on the amount and type of computer use at home and at school.

The major focus of the paper is on teaching and research carried out with Victorian children in grades Prep, 1 and 2. Over the past seven years children in these grades at an inner-city school have used computer-based multimedia software to solve simple problems and produce electronic products at an appropriate cognitive level. Working in collaboration with the teachers of these grades, investigations have been made in the areas of (i) ideas for developing aspects of information literacy, (ii) a project-based learning approach, and (iii) different pedagogical approaches in the classroom.

Keywords: elementary education, learning processes.

1 Introduction

Computers have become ubiquitous at all levels of schooling in developed countries. As technology in general, and information and communication technologies (ICT) in particular, permeate our education systems there is increasing concern that young children are being "fast forwarded" through the basics of educational uses of ICT. It is possible that because of a lack of appropriate professional development, some teachers of young children are emphasising technical skills and the completion of products to the detriment of independent self-paced exploration and understanding.

Haugland (1999) argues that computers and ICT can be used in developmentally appropriate ways with very young children. Discussing when children are ready to learn using ICT she states, "It is my recommendation that computers be introduced to young children when they are about three years of age" (Haugland 1999:26).

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2 Young Children Using Computers

In the last decade of the twentieth century research moved from questioning the appropriateness of using learning technologies with young children to ascertaining which types of computer-related experiences and environments are most effective for learning (Clements 1999). Clements makes the point that not all experiences with computers equally benefit young children's learning, as much depends on the software being used (1999:121). It is also true that the context (the inter-mix between software and the classroom environment) and the actions of the teacher (attitude towards computers in learning and the nature and style of the follow-up to computer use) are vital factors in promoting effective learning with ICT.

A report by the Alliance for Childhood (2000) proposed that computers should be removed from US primary schools. It was argued in the report that computers are dangerous to young children because they pose physical, emotional/social, intellectual, and moral hazards. Harvey (2001) presents a reasoned response to the claims made about dangers to children from using computers as part of the process of learning. It would appear that the report assumes young children spend significant amounts of time each day using computers. However a report by the Kaiser Family Foundation (1999) found that American children aged 2–7 years averaged 4 hours and 13 minutes of media exposure daily, which was subdivided into 3 hours and 9 minutes watching television or videos (1:59 watching their own TV shows, 0:43 watching with parents, and 0:29 watching videos), 45 minutes reading, 8 minutes playing video games, and only 11 minutes on computers (Kaiser Family Foundation 1999:16). This computer time included computer use at both school and home.

This rather insignificant amount of use can be compared with a slightly later study of over 1700 young people aged 5 to 16 in the UK (DfES 2001) which found that 99% of the young people interviewed used computers somewhere, with approximately 90% reporting using computers at school. Almost 75% of the young people had access to computers at home. The young children in this group (ages 5 to 7) were asked to differentiate between playing games and not playing games. On average young children spent 2.2 hours each week playing games and 3.1 hours using a computer for something other than playing games. A breakdown of the DfES (2001) data on computer usage is given in Table 1.

Time spent using a computer anywhere averaged 11.5 hour/week for all students. Of this amount 7.5 hour/week

occurred at home, with 5-7 year old children reporting 4.4 hour/week and 16+ year olds 10.7 hour/week. Among students the majority of reported home use was for game playing (89% for 5-7 year olds) and homework (85% for 11-14 year olds).

At school	At home	At home or school	Elsewhere
93%	75%	98%	1%

Table 1: UK Data on Computer Use by Young People

Haugland (2000a:17) reports that in 1992 there was very little difference in computer use along gender lines for US children. However the DfES (2001) report for UK children found differences between girls and boys of primary school age in some aspects of computer use, as summarised in Table 2.

	Boys	Girls
Using educational CD-ROMs	26%	21%
Accessing the Internet	25%	19%
Drawing pictures	46%	53%
Writing stories	22%	31%

Table 2: Home Uses of Computers by Gender for 5-–11 Year Olds. (DfES 2001:15)

These findings support other research into preferred uses of computers by girls and boys (for example Clements 1998, Kafai and Sutton 1999, Downes, Reddacliff and Moont 1996).

Reviews of published research studies into use of ICT with young children suggest there are many areas of education where technology can benefit learners (Kulik 1994, Finegan and Austin 2002, Clements 1999). Among the benefits noted were improvements in mathematical problem solving and increases in language skills such as vocabulary size and use, reading and spelling. In addition there are references to increased social development and improved social interaction. Because these studies tended to focus on aspects of language or mathematics, they do not report on improvements in young children's technological skills and knowledge.

3 Effective Use of ICT with Young Children

There are specific roles for teachers and other adults interacting with young children who are using learning technologies. Adults determine the physical characteristics of learning spaces. Haugland (1999) argues that for children in the early grades of primary school, each classroom should have a "computer centre" and a collection of developmentally appropriate software. Using the term "learning centre" would appear to be better because it takes the focus away from the technology and in most early years classrooms would be just one of several learning centres. Ideally the computer learning centre will be highly visible with screens able to be seen from anywhere in the room. Use of computers should not be seen and practised as individualistic or something that is hidden from sight because it is not part of the normal learning activities and processes. Having screens visible around the room only becomes a distraction to students when computer use is not one of the everyday learning activities available to everyone.

If children work in pairs at a computer, seats for children should be positioned in front of the monitor and a seat placed to one side and slightly behind for an adult. The roles of an adult sitting near a computer with children should be that of observer, listener and facilitator. Adults should never take over control of the keyboard or mouse from children unless there is some physical danger to the children. If children have a problem they can discuss the problem with an adult. The adult should never be so close to either the children or the computer that children are inhibited in their talk and actions.

Haugland (2000a:16) nominates access, availability and parental collaboration as three factors that can maximise the educational benefits of young children using computers. Recognising that children of all ages might use computers both at school and at home, Haugland presents data indicating a low level of funding and consequential shortages of hardware, software and teacher education for educational ICT in US schools. Increasing numbers of computers are being purchased by schools, but there is no indication that they are being used effectively to enhance student learning by even a majority of classroom teachers. In Haugland's terms, access relates to where computers exist so that children might use them, while availability concerns whether or not children are permitted to use the computers that exist at school or home.

There is an increasing amount of evidence that overall children have more access to ICT at home than they do at school (O'Riordan 1999, DfES 2001). As noted previously (see Table 1) a survey in the UK reported that 99% of almost 1700 children interviewed claimed to use computers somewhere each week. Table 3 shows major home and school uses of computers reported by 5–7 and 7–11 year old children in the DfES (2001) survey.

	Ages 5–7		Ages 7–11	
	Home	School	Home	School
Playing games	89%	55%	88%	39%
Homework or study	4%	NA	7%	NA
Internet accessing	13%	4%	26%	27%
Drawing pictures	60%	54%	45%	66%
Writing stories	15%	41%	30%	27%

Table 3: Uses of Computers at Home and School for 5–11 Year Old Children. (DfES 2001:15&23)

From an educational point of view it is disturbing to note the high incidence of game playing on computers, both at home and at school.

One of the issues concerning young children and ICT is the number of different packages they are encouraged to use. Solomon noted that typically children are introduced to computers by a process of exposure to a range of

software, and that often this "exposure trivializes intellectual pursuits that cannot be completed in five or ten minutes" (Solomon 1986:3). This comment is even more valid today than when it was written.

This brief consideration of research into young children using ICT in schools offers little comfort or assistance to teachers in the early years grades.

4 Curriculum Expectations

An investigation of curriculum proposals in ICT related skills and activities for young children reveals that a range of quite technologically sophisticated knowledge skills are expected. In this section expectations from the UK and USA are briefly visited, while the Victorian state curriculum documents for young children are examined in more detail.

In the UK it is expected that by the end of the foundation stage children will be able to "Find out about and identify the uses of everyday technology and use information and communication technology and programmable toys to support their learning" (QCA 2000:92). The foundation stage commences with children from age three who are in kindergarten or nursery school, and concludes with the reception year prior to children formally commencing school. The reception year in the UK appears to equate to kindergarten in the Australian context.

National Standards in the US (ISTE 2000) anticipate that before the end of Grade 2 students will achieve the following performance indicators.

5 GRADES PRE K–2 Performance Indicators:

All students should have opportunities to demonstrate the following performances.

Prior to completion of Grade 2 students will:

1. Use input devices (e.g., mouse, keyboard, remote control) and output devices (e.g., monitor, printer) to successfully operate computers, VCRs, audiotapes, and other technologies. (1)
2. Use a variety of media and technology resources for directed and independent learning activities. (1, 3)
3. Communicate about technology using developmentally appropriate and accurate terminology. (1)
4. Use developmentally appropriate multimedia resources (e.g., interactive books, educational software, elementary multimedia encyclopedias) to support learning. (1)
5. Work cooperatively and collaboratively with peers, family members, and others when using technology in the classroom. (2)
6. Demonstrate positive social and ethical behaviors when using technology. (2)
7. Practice responsible use of technology systems and software. (2)
8. Create developmentally appropriate multimedia products with support from teachers, family members, or student partners. (3)
9. Use technology resources (e.g., puzzles, logical thinking programs, writing tools, digital cameras, drawing tools) for problem solving, communication, and illustration of thoughts, ideas, and stories. (3, 4, 5, 6)
10. Gather information and communicate with others using telecommunications, with support from teachers, family members, or student partners. (4)

Numbers in brackets after each point refer to these categories of Technology Foundation Standards:

1. Basic operations and concepts
2. Social, ethical, and human issues
3. Technology productivity tools
4. Technology communication tools
5. Technology research tools
6. Technology problem-solving tools

(ISTE 2000)

In the Australian context, the Victorian Curriculum and Standards Framework II for Technology (CSF II 2000) includes suggested computer activities and performance indicators that appear beyond the capabilities of many 5 and 6 year old children. Even by the end of their first year of primary school (called Prep year in Victoria) most of these children are only beginning readers and writers, and require considerable adult assistance in order to successfully "write a simple sentence about a personal experience", or "locate information on a topic of interest and talk about the content," both of which are suggestions for the English language key learning area.

Table 4, below, provides a summary of ICT related skills and knowledge suggested for young children in Victorian schools. It should be noted that the CSF documents make it explicit that the curriculum developers' expectation is that in the primary school, Grades Prep to 6, ICT will be integrated into all key learning areas and not taught as a separate, stand-alone subject. In the table CSF Level 1 comprises the first year of school (Prep grade) while Level 2 is for children in the second and third years of school (grades 1 and 2). Table 4 lists ICT areas where suggestions are made for use by young children, and only one key learning area has been included for each of the levels that relate to children in the early years of schooling.

Many of the premises on which the CSF II curriculum documents are based, including the integration or infusion of ICT into all the key learning areas, are appropriate for young children. However, as Table 4 demonstrates, at times the expectations of curriculum developers do not appear to match the cognitive, physical, and affective development of children aged seven or less.

	Level 1 [age 5] English	Level 2 [age 6-7] Mathematics
File management	saves data to existing files	creates and saves files
Word processing	keys simple data into prepared files- e.g. writes a simple sentence about a personal experience	keys data, edits for accuracy and prints files
Graphics	creates freehand pictures- e.g. draws animals to match initial sounds or letters	paints and edits pictures- e.g. creates a display of data using pictographs
Multimedia	accesses information from CD-ROMs - e.g. locates information on a topic of interest and talks about the content	creates simple files using different types of data- e.g. constructs simple tessellations or arranges shapes according to attributes
Electronic communication	receives and reads data e.g. reads an e-mail message from the teacher	composes and sends messages- e.g. queries a friend or relative about the price of particular toys in shops in their area

Table 4: Curriculum Suggestions for ICT Use by Young Children. (CSF 2000)

6 One School's Approach

Possibly the best guidelines for teachers, and parents, were written in the early years of educational computing by people strongly influenced by the developmental theories of Piaget. Solomon (1986) was a member of the early Logo community that developed around Seymour Papert at MIT in the 1980s. Papert had worked in Geneva with Piaget, and consequently much of the original research into learning with Logo was based around Piagetian theories. Duckworth (1996) provides insights into the way children in the early years of schooling grapple with simple science experiments that appear to contradict their intuitive beliefs. For many young children there is a similar dilemma between what they anticipate from an action with a piece of software, and what actually occurs. Piagetian learning researchers hypothesise that there are three routes to knowledge: perceptual, action, and conceptual. In each case something the learner has seen, done, or thought about creates links with a new situation.

> In the course of trying to solve practical problems, children spend time reorganizing their levels of understanding; in real situations, children develop multiple access routes to their knowledge.
>
> (Duckworth, 1996:49)

This then should be the aim of teachers using ICT with young children—the way technology is used and the cognitive challenges posed to learners should extend knowledge by adding to what is already known.

This section of the paper is a report of practical teaching and research carried out with Victorian children in grades Prep, 1 and 2. Over the past seven years children in these grades at an inner-city school have used computer-based multimedia software to solve simple problems and produce electronic products at an appropriate cognitive level. In collaboration with teachers of these grades, investigations have focused on (i) ideas for developing aspects of information literacy, (ii) applying a project-based learning approach, and (iii) implementing different pedagogical approaches to classroom use of ICT.

Teachers at this school have made a deliberate attempt to limit the number of software packages used with young children in class, without unduly limiting potential learning activities across all areas of the curriculum. In this school LCSI *MicroWorlds* is the only software used at all grade levels from Prep to 6. It is the package most commonly used in the early years classes, although *KidPix* is the first content-free package used formally. In addition, when the teacher believes it is developmentally appropriate, Prep grade children are given opportunities to explore parts of the *Maths circus* and *James discovers math* packages.

One significant feature of *MicroWorlds* is that a number of different aspects of ICT can be investigated within the one package. For example, young children might begin their exploration of *MicroWorlds* through the draw/paint facility. In this school this is a natural follow-on from the use of *KidPix*. When it is cognitively appropriate this can be extended to using stamps of the shapes available in *MicroWorlds*, and then constructing and stamping their own shapes. At all times the emphasis is on providing the young learners with cognitive challenges in which the technology can assist without being the focus of attention.

To increase the cognitive challenge and to focus learning, teachers can prepare a microworld for learners. This is a form of template that learners explore within given constraints. The "single-key" microworld is one of several used by early years students in this school. It introduces learners to basic concepts of turtle geometry and at the same time reduces reliance on keyboard skills. Logo commands such as fd 88 are replaced by a single letter, most commonly "f" for forward commands. The microworld contains a limited set of single-key commands such as *f, b, r, l.* Initial settings might be for forward and back movements of 88 units and left and right turns of 90^0. As understandings of angles and shapes are developed the amount of turn linked to *l* and *r* can be changed to angles of 45^0, 60^0 or 30^0.

The single-key microworld with turns set at 90^0 offers an opportunity for young children to look for similarities and differences, and to investigate mathematical properties of shapes such as squares and rectangles. Experience with many different classes has shown that children in grades Prep and 1 quickly learn to generate these shapes and articulate some of the basic mathematical properties. The teacher has a crucial role in making what has been learned explicit to the students. This should occur first

during the time set aside for sharing and reflection on successes and the problems that have been encountered.

Most children, even in their first year of school, are able to work on projects that extend over weeks or even months, as long as they revisit the project briefly on a regular basis. Figure 1 shows a page from an electronic science diary. Using *MicroWorlds* the teacher created a template comprising the text box with a weekly heading, and buttons to connect to other pages. Each week children were encouraged to record the growth progress of a seed they had planted and were caring for. Working individually children entered a comment in the text box. Later the teacher asked the child to read the comment and then re-entered it with corrected spelling and grammar. Creating electronic books in this way enables children to work at their personal level of development while producing a product that can be published on the school's intranet.

Figure 1: Electronic Science Diary, Prep grade

While developing an electronic science diary young children are learning about many aspects of ICT. Prior to this stage children experience activities and challenges specifically designed to develop ICT skills. Although the meaning of Easter might not be covered in Prep classes, most children will be aware of Easter eggs. Figure 2 shows a simple task based on Easter eggs and designed to introduce or reinforce skills in electronic copying, pasting and erasing. Children are presented with the outline of the

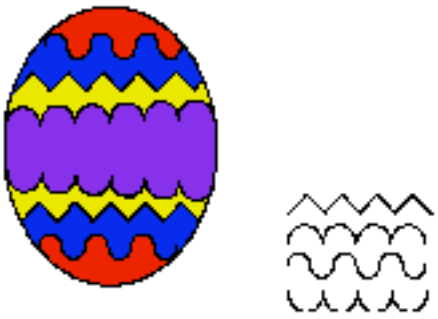

Figure 2: Easter Egg Task, Prep Grade

egg and several patterns of wavy lines. Their task is to copy and paste all or some of these lines to make a pattern on the egg, which is then coloured in. Lines that lie outside the egg are erased. The filling with colours can show children where mistakes such as not continuing a pattern line from one side to the other, or of erasing part of the shell, have been made.

In Grades 1 and 2 children are introduced to animation following several lessons using turtle geometry to generate mathematical shapes. Initial workshops focus on entering instructions into the *MicroWorlds* command centre to control the turtle. This enables children to generate a range of shapes. In order to draw regular polygons they are shown how to put instructions into a turtle, and have the turtle carry out the instructions until stopped manually. This allows for exploration of the role of side length, for example fd 88, and how much the turtle turns, for example lt 60.

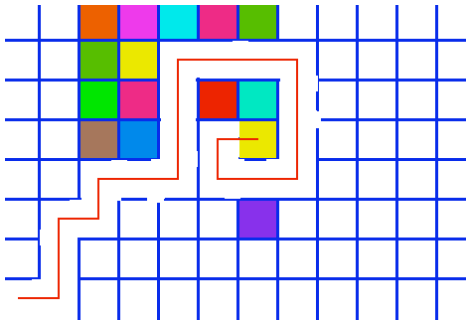

Figure 3: MicroWorlds Maze Grid

Another single-key activity is shown in Figure 3. Here the microworld draws the grid and positions the turtle in the lower left corner of the screen outside the grid. In their first interaction with this microworld children find a simple path already made, and their task is to guide the turtle through the maze without touching the grid lines. In the example shown Grade 1 children have been presented with the grid and have been asked to erase enough lines to make a maze path, and then move the turtle along the path. Again, at the conclusion of computer sessions there is time for reflection and discussion on what has been accomplished and learned. Using their own words, and at their own level of development, children discuss what they have noted about mathematical concepts such as parallel lines (the turtle always moves parallel to one set of grid lines) and the congruence of right angles.

Although *MicroWorlds* was used for these examples, similar activities are possible using *KidPix*, word processing packages with a draw capability, or any other drawing program.

7 Conclusions

In any learning environment for children, ICT based activities should never replace the use of concrete materials and manipulatives. Children must be permitted to explore books, measure water and sand, draw with pencils and crayons, and write on paper, together with all the other traditional experiences of kindergarten and primary school. However there are many ways computer-based activities can be used to complement and enrich the learning experiences of young children.

Over the past decade many studies have indicated that there are real and measurable educational benefits for young children who have ICT integrated into their classroom experiences. These benefits cover content in many curriculum areas as well as affective and personal development.

Research into effective ways of using ICT with children in the first three years of schooling has shown that when appropriate guidelines are followed (for example Haugland 2000a and b, NAEYC 1996), there is an abundance of computer-based learning activities and experiences in almost every curriculum key learning area available to classroom teachers. The examples presented have shown that it is within the capability of teachers to develop activities that offer some choices to young learners, are linked to curriculum learning objectives, and are small group activities that foster communication and social skills.

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