

Embedding Computer Technology in Developmentally Appropriate Practice: Engaging with Early Years Professionals' Beliefs and Values

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The use of computers in early years has become a contentious issue, with advocates calling for more Information and Communications Technology (ICT), more machines, better software, and more training for professionals, while other groups call for “a moratorium on the further introduction of computers in early childhood and elementary education” (Cordes & Miller, 2000).

The authors of this article would like to declare their allegiances here: they are in favour of computers in the same way that they are in favour of books, pencils, worksheets, Lego, jigsaws, junk modelling, role play, and circle time. Activities and equipment in early years are, in themselves, neither positive or negative: it is the way in which they are used which is meaningful. Any of the things on their list can (and have) been criticised as retarding or limiting children’s development. They believe that children need opportunities to interact with the world at developmentally appropriate levels, to “own” the interactions, forming personal, relevant “mental furniture,” organising their learning in partnership with peers and sensitive, scaffolding adults. Such activities are appropriate in that they actively engage learners and developmental in the sense that they help to support the development of children’s learning. ICT has a place in this, and the burning questions are not *whether* computers should be used but *where* and *how* ICT can be used to enlarge and enrich young children’s experience of learning.

This article is divided into three main sections. In the first, the findings from a major research project investigating the effective use of computers for math and language teaching funded by the UK government are briefly summarised. This summary focuses on where these findings apply to early years teachers and their beliefs and practice in using computers. The full findings and further analysis of the interaction of teachers' beliefs and their practice and professional development are published elsewhere (Moseley, Higgins, Bramald, Hardman, Miller, Mroz, Tse, Newton, Thompson, Williamson, Halligan, Bramald, Newton, Tymms, Henderson, & Stout, 1999; Higgins & Moseley, 2001). These findings are then set in the wider context of research into computer use, particularly in early years settings in the central section of the article. The final section contains a description of one example of an action research undertaken in collaboration with the teachers involved in the UK research project which illustrates the authors' understanding of how developmentally appropriate activities for young children in mathematics can be undertaken using computers.

EARLY YEARS PROFESSIONALS AND COMPUTERS: UK RESEARCH

In debating the appropriate use of computers in early years education there is an underpinning level to explore: whether early years professionals feel that ICT can or should form part of their ideal, espoused practice. A research project, funded by the UK government's Teacher Training Agency (TTA) (Moseley et al., 1999; Higgins & Moseley, 2001) explored teachers' constructs relating to teaching and learning and found that adopting ICT had a reciprocal relationship with teachers' beliefs. Other research has also indicated that teachers are likely to adopt practices with computers which reflect their beliefs about teaching and learning (Drenoyianni & Selwood, 1998) and, while the relationship between teacher's practices, skills, and beliefs is complex (Wild, 1996), there is some evidence that the adoption of ICT can have an impact upon teachers' thinking about effective organisation and management of learning (Dwyer, Ringstaff, & Sandholtz, 1991) and upon teachers' beliefs, teaching strategies and assessment activities (Sandholtz, Ringstaff, & Dwyer, 1997).

An exploration of 75 teachers' thinking about teaching and learning activities using construct elicitation and ranking exercise was undertaken in the project. Findings from this exploration were related to other information such as computer provision and use as reported in questionnaire responses. This information was then compared with data about the relative attainment

of children in reading and mathematics in these teachers' classes using "value-added" or relative pupil progress data from the Performance Indicators in Primary Schools project (PIPS) based at Durham University in England. One subgroup within the research project was made up of 29 teachers of 4-5-year-olds. An analysis of their thinking revealed that the only pattern of thinking which had a positive significant link with gains in pupils' attainment was having a negative attitude towards using ICT (a significant correlation of 0.45* was found with a combined measure of relative pupil attainment for math and reading, and a correlation of 0.50** for reading alone (see Higgins & Moseley, 2001, p. 200)). Or, in other words, teachers of 4-5-year-olds who were sceptical about the value of computers were more likely to be teaching classes where their children made more progress in math and reading. The interpretation of this link between scepticism about the use of computers and effective early years teachers was further confirmed by questionnaire data, which revealed that overall "value-added," or relative pupil attainment, was significantly higher for teachers of 4-5-year-olds who believed printed resources, such as books, to be better than ICT resources ($r=0.42^*$) and who believed their ICT skills to be inadequate for using ICT in their teaching ($r=0.43^*$).

The authors considered that this finding was a significant challenge to the effective integration of computers into early years settings, but did not interpret it as indicating that computers themselves were detrimental to learning. Rather they inferred that the teachers' beliefs were influencing the way that computers were being used. When the project examined the self-reported ICT skills of these teachers and the length of their teaching experience in relation to types of ICT usage, it emerged that more experienced reception teachers tended to have more limited ICT skills ($r= -0.65^*$) than those who had entered the profession more recently. In addition, there were some interesting links with the types of use of computers reported by the teachers and their self-reported levels of ICT skill (Table 1).

Table 1
Computer Use Linked to Experience and Reported Skill Level

Computers used:	By more experienced teachers	By teachers reporting good ICT skills
for information retrieval	infrequently ($r= -0.66^*$)	frequently ($r=0.69^{**}$)
by pupils who finish their class work	infrequently ($r= -0.66^*$)	frequently ($r=0.86^*$)
as a free choice or		
playtime activity	infrequently ($r= -0.58^*$)	frequently ($r=0.63^*$)

More experienced teachers (who tended to report relatively low levels of computer skills) were likely to use computers infrequently for information retrieval, for children who were finished their work or as free choice activities. By contrast, teachers who reported higher levels of computer skills (and who tended to be less experienced) were likely to use the computer much more frequently for just these types of activities.

Other data from the project found that computers are commonly used in reception classes (4 - 5-year-olds) as a reward or extension activity available to pupils who have finished other work or activities (Moseley et al., 1999). The clear implication from the data gathered in this research project is that this may be counter-productive so far as children's learning is concerned.

In brief, the research findings indicate that it is not a good idea for computers to be used in reception classes to keep some pupils busy, or simply as a motivational attraction "playing on the computer" or to learn how to find information simply as a computer skills exercise rather than for the purpose of using that information. The teachers who do these things are likely to be computer-literate and to be relatively recent entrants to the profession. More experienced and successful teachers of young children are less skilled and less confident in using computers. Our interpretation is that computers are therefore best used with young children when there are clearer learning objectives which are integrated with the other teaching and learning activities. Full details about the research project and the exploration of teachers' thinking and ICT are reported elsewhere (Moseley et al., 1999; Higgins & Moseley, 2001).

WIDER RESEARCH LITERATURE

To contextualise these findings about espoused practice and to try to understand the implications for effective use of computers with young children, a literature review was conducted to explore some of the constraints and incentives operating on and around early years professionals which might influence the uptake and integration of ICT. The reading prompted the authors to an analysis on three levels (Figure 1).

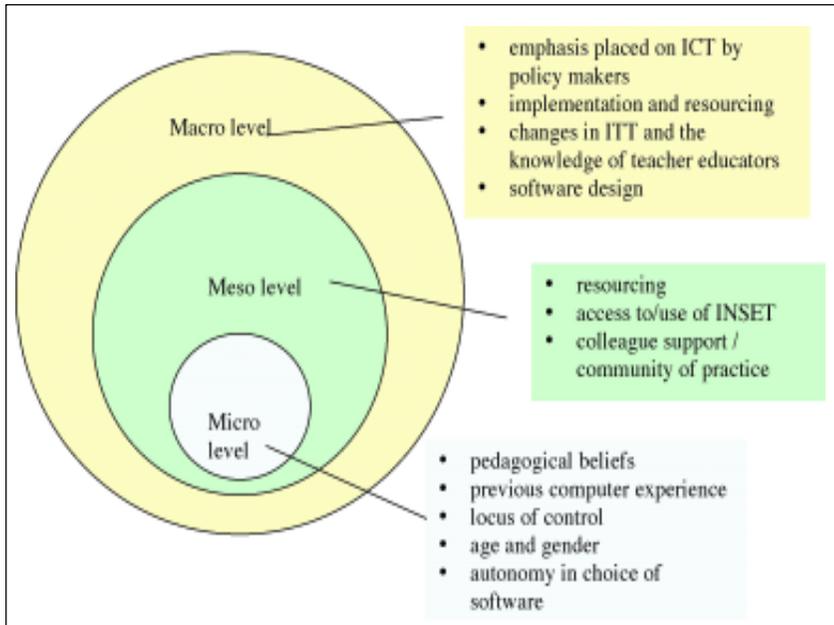


Figure 1. Levels of influence on the uptake of ICT in early years settings

Macro Level: Policy, Rhetoric, and the Gap Between Ends and Means

Too often the assumption is made that student teachers and teachers need to know how to use computer technology without first asking why they need to know and importantly, what they need to know: computers are often presented as an imperative (Wild, 1996, p3).

The enthusiasm of politicians for technology—be it “white heat” or “the information superhighway”—has been operationalised over the last decade in the UK in terms of significant investment in hardware for education (£1.4 billion sterling or nearly \$2 billion US), recently (and perhaps belatedly) followed by a £230 million (\$320 million) programme of training for teachers funded by the UK’s national lottery. What is missing, however, is a clear understanding underpinning this construction of “need” and this absence is based, arguably, upon “a distrust of a more theoretical analysis of the role of the computer in education and therefore society” (Selwyn, 1997).

This may go some way towards explaining the relatively slow pace of change in preservice teacher education or Initial Teacher Training (ITT), both in terms of the computer literacy of beginning teachers and the ability of teacher educators to adapt their pedagogy to new technology and to model new ways of teaching to students.

There is a widely held assumption that postgraduate students currently entering initial teacher training programs will have a basic level of computer literacy as a result of the expansion in computer use in schools and colleges during the 1990s. Hughes (1997) argued that the *laissez-faire* introduction of computers into schools and colleges inevitably led to the concentration of small numbers of machines in the hands of experts—60% of teachers in this survey believed that access to hardware was a burning issue. This has been likely to exclude early years settings as younger children have tended to be given older computers (Bilton, 1996). Furthermore, as previously discussed, experienced early years teachers are likely to be more sceptical about their value in the classroom.

The limitations of initial teacher education programs in preparing new teachers for technology may in part be due to the general relatively low levels of computer sophistication amongst teacher educators: the pattern of teacher educators to be older and less computer-literate is repeated in the US, Denmark, and France (Simpson, Payne, Munro, & Hughes, 1999). The conclusions of this research was that while teacher educators pay lip service to the importance of ICT, they feel personally unable to keep up with developments and tend not to “model” ICT as a teaching tool for their students.

We might have something within the course documentation which might say “We believe that ICT is a good thing”—a bit like apple pie and motherhood. But we haven’t got any kind of strategic plan to take that forward in a really coherent way. (Simpson et al., p. 253)

It also seems likely that the early years teacher educators may share levels of scepticism about the value of computers for teaching young children, reflecting the patterns of belief found in the research discussed, and that this is likely to exacerbate the relatively slow pace of change.

Software developers are often blamed for the mismatch between teachers’ pedagogical styles and the instructional styles of programmes (e.g., Kent & McNergney, 1999) and, in particular, material for the early years is criticised for not being developmentally appropriate or for being overly didactic. However, it is unrealistic to expect developers to provide tailored software when professionals themselves are sceptical or unsure of what

they want or how it can be used. The authors therefore suggest that here is a complex inter-relationship between professional self-awareness, access to training, and autonomy in the selection of appropriate software and hardware, which needs to be more critically explored.

Meso Level: Management and Culture of the Setting

Teachers of young children in the UK work in a variety of settings: nursery schools, which are wholly early years focussed, first schools catering to children aged 3- 9-years-old, and primary schools with children aged 3-11. There will be differences between these types of settings which will have an impact on teachers' access both to hardware and to colleagues' support and advice. At a more fundamental level, however, there are a myriad of influences on the culture of a school, which will impede or nurture reflection and innovation.

In early childhood debates, there have been, broadly, two schools of thought about computers: that they are potentially detrimental to children's social and intellectual development (Elkind, 1996; Harbeck & Sherman, 1999; but see Fatouros, 1995, for a rebuttal of these concerns) and a more inclusive view that "computers are ...just another enrichment option for exploration and manipulation." (Liu, 1996: see this paper for a review of positive research on early skill-building through ICT).

However, for many early years settings there is a fundamental problem of resources. Bilton (1996) in a study of 65 nursery settings in the UK found that 13.9% had no computer at all. Some settings which had computers, used them only for administration. All settings used older computers: "nursery always gets the rejects" and many were unable to run CD-ROMs (Bilton, p. 69; Wood, Willoughby, & Specht, 1998) and over 70% had ratios worse than 1 computer for 30 children. Around one third of the respondents had had formal ICT inservice training, while over half relied on colleagues and self-instruction. Only 7.5% reported that they owed their computer skills to initial training. Sexton, King, Aldridge, and Goodstadt-Killo-ran (1999) found positive correlations between formal training and a positive attitude towards ICT in early years professionals and moreover, found that as a group, early years staff tended to have external loci of control in relation to ICT and relied on others to teach them to use computers.

Another study (Landerholm, 1995) found that while 90% of early years teachers had extremely positive attitudes towards computers only 51% were actually using one in their classroom and just under a third had no access to

a computer at all. Similarly, while over 70% of early years settings in one study did not provide ICT training for staff, 83% of settings intended to purchase more computers (Wood et al., 1998). The picture is with regard to provision may be changing, but it is only the first stage: “the presence of technology in early childhood education is becoming more and more a hardware reality, but subsequent work is needed to transform it into a technology-based learning reality.” (Mioduser, Tur-Kaspa, & Leitner, 2000, p. 61).

So is ICT embedded in classroom practice or is it a “bolt-on?” Several commentators in the field (see, for example, Budin, 1999; Sandholtz et al., 1997) have constructed models of the integration of technology into teaching (Table 2).

Table 2
Integrating Technology into Teaching (Sandholtz et al., 1997)

Stage 1 Entry	Teachers are not comfortable with technology and typically don't use it.
Stage 2 Adoption	Teachers use technology to support traditional methods. Teachers have mastered management issues but have not changed their teaching style.
Stage 3 Adaptation	Teachers find that the use of technology saves time and allows students to perform higher order thinking. They may adapt their style to give better feedback.
Stage 4 Appropriation	Teachers have confidence and skill to use technology to develop new methods of instruction and to exploit the communicative and collaborative features of computers.
Stage 5 Invention	Teachers have integrated the potential of technology with their personal vision of teaching and learning. They begin to develop new learning environments.

Expectations that teachers will progress rapidly through these stages remain high. “We ought to be able to rely on educators—themselves information specialists—to lead the way in providing balanced perspectives on a range of IT mediated learning” (Luke, 1999, p. 99). However, it is clear that the majority of professionals “peak” at Stages 2 and 3. “Essentially most teachers adopted a ‘set it and forget it’ routine” (Miller, DeJean, & Miller, 2000, p. 131). The “overtly optimistic tone” (Selwyn, 1997) of many commentators inadvertently serves to widen the gap between the small band of enthusiasts and publicists and the vast majority of under-informed, under-resourced, and under-trained practitioners.

The organisational and pedagogical culture of the setting will have an impact on individuals' abilities to embrace change (e.g., Menmuir & Christie, 1999), in particular, more reflective communities of practice will find it easier to identify and articulate their pedagogical beliefs (Nias, 1989). This enables professionals to assess congruence or dissonance between their practice and the design of computer software or websites or, more broadly to decide *for themselves* the place of ICT in their teaching.

Micro Level: The Individual's View of Themselves, Their Practice, and Technology

The reflective practitioner can only evaluate the role of any activity or resource in his or her practice in terms of its' congruence with their fundamental beliefs about effective and appropriate practice. In the same way that developmentally appropriate practice for young children aspires to provide learning experiences which are shaped, personalised, and made relevant by the child's own interests, the effective adoption of ICT by practitioners is underpinned by a sense of ownership and relevance.

A key element appears to be the extent to which ICT resources match teachers' modes of instruction and pedagogical beliefs (Moseley et al., 1999). A review of the use of electronic books (Lewin, 2000) found that while they had only a moderate impact on pupil learning, they were valued by teachers because aspects of the software—for example the “hint” buttons—tallied with their practice. The limitations of individual instructional programmes (e.g., van Daal & Reitsma, 2000) are only serious if they are being used in isolation from the other learning experiences in the classroom. Miller and colleagues (2000) noted distinct differences between the instructional modes of an Integrated Learning System (ILS) and teachers' normal pedagogy with regard to phonics. Although most teachers in the study were aware of this incongruity, they either felt it to be unimportant or responded in a way which reflected both helplessness and hostility. “What am I supposed to do,...Give up everything I do just to please the damn computer?” (Miller et al., p. 131).

This helpless attitude does not bode well for the quality of pupil learning. Underwood's (2000) study of the effectiveness of ILS implied that it is various school and teacher-related factors which really make a difference, in particular where “teachers made significant interventions in the management of the learning environment, wresting some of the control back from the machine” (Underwood, p. 143).

Clearly, the impetus lies with the individual teacher. Wishart (1997) reported that, in initial teacher training, individual locus of control is a significant factor in the willingness to use ICT. Individuals with a more internal locus of control tend to be older and male, moreover, men are also more likely to own and have experience of using computers. This has implications for early years settings, where the professional population, in the UK at least, could be characterised as being composed of younger women who may have had computer experience but may be less robust in terms of locus of control and older women who are less likely to have had access to computers.

The rejection of ICT cannot be dismissed as mere technophobia; a helpful concept here is “not-learning” which can have a definite purpose (Burniske, 2000): professionals must construct a robust sense of self to survive. Burniske refers to Herbert Kohl’s description of the concept:

Not learning tends to take place when someone has to deal with unavoidable challenges to her or his personal and family loyalties, integrity and identity. In such situations there are forced choices and no apparent middle ground. To agree to learn from a stranger who does not respect your integrity causes a major loss of self. The only alternative is to not-learn and reject the strangers’ world. (Kohl, 1994, p. 6).

Nevertheless, early years practitioners are still grappling with methods to “bring the computer to children in a way that conforms with development” (Shilling, 1997, p. 253). Labbo (2000) argued that the traditional pedagogical concerns embedded in shared stories can be echoed and supported through CD-ROM talking books, although teachers themselves must overcome their technological shortcomings to mentor reading strategies using the computer, rather than restricting themselves to the management of time and “mouse wars,” important though these social issues can be, particularly when as Labbo observed, children’s enthusiasm for computers can lead to individuals spending up to 45 minutes actively engaged.

The “engagement” benefits of computers (Mioduser, Tur-Kaspa, & Leitner, 2000) may also enable teachers to develop more collaborative learning, since as Crook noted “the reason for raising doubts about [young children’s] potential as collaborators arises from observations of what goes on in classrooms. But if we glance into a school playground...we soon notice children actively managing collaborative routines.” (Crook, 1998, p. 243). Or, as Wood and colleagues put it: “Computers appear to facilitate development without the loss of fun.” (Wood et al., 1998)

The integration of the computer into play and nondirected activities as well as directed reading and writing tasks, which Shilling (1997) and Moseley and colleagues (1999) observed in their research, signals a level of adaptation and embeddedness in both teachers' and children's thinking about learning which can transcend the management issues. This integration should be physical in order to have significant effects: Shilling emphasised Haughland's findings (1992) about the need to position the computer "in a visible, highly active area" to allow for innovative and playful exploration and in constant use, so that the rules for peer interaction can develop and become normalised (Labbo, 2000; Lomangino, Nicholson, & Sulzby, 1999).

The goal of encouraging children's independent learning is central to early years practice and research by Russell, Series, Wallace, Brown, and Skilling (2000) suggested that this can be supported by the use of a computer-supported pronunciation programme because "children considered the computerised system to be 'non-judgemental' and they were therefore more likely to attempt an unfamiliar word when talking to the computer" (p. 172). The potential for the computer to provide a mediated space for learners in which they can take risks is an important one as the early years curriculum in the UK becomes more assessment-driven. Schery and O'Connor (1997) suggested that computer interventions may also be more effective if the mentoring process is carried out by adults other than the teacher who have a greater cultural congruence with the children (i.e., parents, community helpers, or other children). Obviously, there are significant resource implications which can hamper the most enthusiastic practitioner but even if the machine enters the classroom environment for a short time, the management of time and space will have a profound impact on the variety and depth of children's learning.

The implications of this review for early years practitioners are that, while ICT uptake is influenced by important external factors relating to policy, resourcing, and the culture of their school, at a fundamental level the individual teacher has an opportunity for autonomy in their practice. By articulating their core beliefs about children's learning it is possible for teachers to make informed judgements about how they want to support and extend that learning and to proceed from that to an assessment of whether ICT can aid them. The next section provides an example of one teachers' use of ICT to extend math skills in a way that fit with her teaching beliefs and style of management, but extended the integration of the use of computers into her professional practice.

EMBEDDING IN PRACTICE: COMPUTERS AND COUNTING

This vignette is drawn from the final phase of the UK research project previously discussed. The findings from the earlier phases of survey and observation were used to design a series of collaborative action research projects intended to raise children's attainment in math or language through computer use (Moseley et al., 1999). The results from standardised test data suggested that the teacher was able to use the computer-based activities effectively as part of her teaching to support the development of her pupils' counting skills as the mean standardised score of the class improved from 82.6 to 97.3 in three months.

This school where the action research took place is in an inner city area. A high proportion of the parents are unemployed and the area has been subject to several government funded regeneration initiatives. Over 70% of pupils receive free school meals. Pupils are achieving below national expectations on entry to the school; however, the school is recognised as being effective at raising standards of achievement. The teacher had been at the school for six years when the project took place and had usually taught the Reception Year (4–5 year olds). When planning activities she liked to make links between different activities and to draw out connections for the children. During an interview undertaken as part of the research project she remarked: "...they might need work on number recognition, or using number lines, and it isn't always linked. But usually we do something that is to do with counting, a counting rhyme or acting out a song which is linked to other activities."

This approach is consistent with the UK's National Numeracy Framework (Department for Education and Employment, 1998) and its recommendations for the Reception year and with research on effective teachers of mathematics (Askew, Brown, Rhodes, Johnson, & Wiliam, 1997) where developing connections within and between mathematical activities was a feature of more effective primary (4-11-year-old) teachers.

At the beginning of the summer term, when a baseline test was conducted, some pupils were making errors in reciting the number names accurately (particularly in terms of stable but inaccurate counting sequences in the numbers from 13-19 and at the decade transitions such as 29 to 30). Some children also had unstable number word sequences from 8–20. Most had inaccurate touch counting skills, and strategies which led them to give an incorrect total at the end of a count, particularly for collections of 6–15 objects, and were also unable to identify the correct written numeral to go with a number name in various counts up to 20. These matched previous

findings of other researchers (e.g., Fuson, 1988), though are more typically found with slightly younger children (3–4 years).

The research team and the teacher therefore agreed to tackle these particular areas of counting skills using some computer-based activities. After negotiation and discussion the focus for the project was the development of pupils' counting skills using a painting program (*Kid Pix* – Broderbund Software). Like many painting programs aimed at young children, the software has the facility to let children stamp a variety of pictures onto the screen. Children choose a stamp and click with the mouse to place it. An additional feature of *Kid Pix* is that it has numeral stamps with sounds, so when the stamp for the number three is selected, for example, the computer says "three." The teacher therefore planned to use the software over the course of the term to create a range of "counting pictures" (Figure 2).

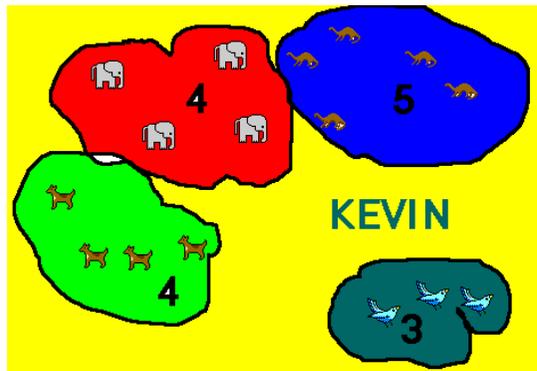


Figure 2. A child's counting picture

Using the painting software in this way enabled her to use the computer in the classroom and in the school's computer room more flexibly than previously. The programs she had used for counting before had focused only on numeral recognition and set-to-symbol or symbol-to-set skills and matching tasks. As many of the children had incorrect stable portions or unstable portions in their counting sequences up to 10 (Fuson, 1988) this was inappropriate for the majority of the children. The teacher commented: "The *Kid Pix* program was quite different from anything I've used before, because the programs we've used before to support numeracy had been very closed."

The children were introduced to the program systematically. Small groups of five or six children were taught how to use the program in the school's computer room by the teacher or the teaching assistant. They then had an opportunity to practice these skills on the computer in the classroom in pairs or individually. Towards the end of the project larger groups were able to use the computer room and even on some occasions the whole class of 28 children were using 15 computers with the support of two adults.

The teacher also used diagnostic information from the baseline test. It gave her detailed information about the particular counting errors that specific children were making. These were discussed as part of the research and development work. In particular the typical error patterns were analysed and particular skills tasks were identified as potentially helpful for groups or for individual children. In addition to the work using ICT, she planned other number activities to support particular skills for groups of children in the class. The teacher wanted children to be able to practise specific aspects of counting and therefore emphasised different aspects of counting skills with different children. Although the tasks were similar and the children considered them the same—"making counting pictures"—in her interaction with the children the focus of discussion and specific practice of skills varied (Table 3).

Table 3
Targeting Specific Skills

Skill	Activity	Focus
Reciting number names up to 10	Counting, stamping and repeating numbers. Clicking along the numeral stamps and saying the numbers with the computer. Counting other children's work.	Number name sequence: <ul style="list-style-type: none"> ● Correct portion ● Stable/incorrect portion ● Unstable portion
Touch and count practice to 10	Counting co-ordinated with stamping (clicking), recounting on screen, counting on print-out.	Check for "skim" and "flurry" errors
Number words to 20	"More than 10" pictures Making animal/field pictures "Counting house" pictures	Number name sequence: <ul style="list-style-type: none"> ● Correct portion ● Stable/incorrect portion ● Unstable portion
Touch and count practice to 20	Counting co-ordinated with stamping (clicking), recounting on screen, counting on print-out.	Check for "skim" and "flurry" errors

The teacher thought that having children create these mathematical pictures, and count out loud as they did so, enabled them to use the ICT more independently. The children were able to use the program to make a variety of counting pictures over a period of just over two months. Each child completed on average two counting pictures each week, either in the computer room or on the computer in the classroom.

Once the children started the activities the teacher encouraged them to count the number of different items in the pictures as they used the stamps. Then she encouraged them to count again once the picture was completed through reviewing what they had done; sometimes this was undertaken as a class activity using printed versions of the pictures. In addition, using the numeral stamps enabled the children to hear the number names and associate the correct symbol with their collection of objects.

These activities were chosen to complement other class and group counting activities which the teacher had also planned. She was able to integrate the creative and exploratory activity that the children did in the computer room with counting and number activities in the classroom. She felt that in the past she had focused on activities for sorting, comparing, and matching, and had not developed the children's use of language in number and counting sufficiently. The teacher reflected on what she saw as the value of the approach: "We didn't have much in the way of numeracy [math] materials, whereas using the painting program has really helped, and the children have used a lot more mathematical language."

The teacher valued the opportunity to use key mathematical vocabulary as she worked with children. She also felt it was important to review the finished pictures with them so that their work had a purpose and so that she could assess their counting skills. This could be done with an individual, a small group or with individuals in a whole class review time.

The pictures were also saved and incorporated into a basic desktop publishing program, which combined text and pictures. These were printed out and laminated for the children to complete number tasks with dry-wipe pens (Figure 3).

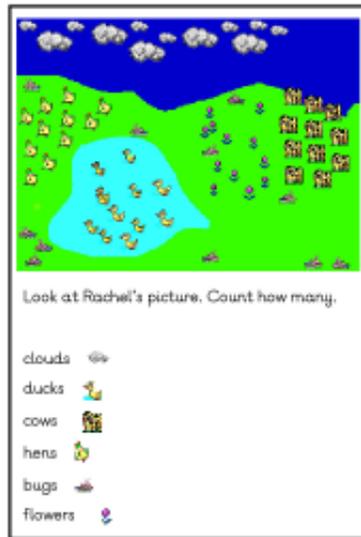


Figure 3. A counting resource created from a child's counting picture

One further benefit from this approach was that the children could create counting pictures to use away from the computer, or to take home to share with parents. This aspect was valued by the children and encouraged them to create a range of pictures. Part of the development of the pupils' skills may therefore have come from this home-school link. Schery and O'Connor (1997) argued that computer interventions for young children may be more effective if the discussion is mediated by adults other than the teacher.

This is an example of the kind of computer-enhanced learning which, the authors believe is in tune with developmentally appropriate practice. The children's level of understanding and skills are sensitively observed and extended by the teacher through the activity. The children have ownership and agency in the development of their learning and the management of the activity as well as clearly enjoying and being engaged by the experience.

CONCLUSIONS

Experienced early years professionals are likely to have views about the use of computers that reflect their beliefs about teaching and learning more generally. They are likely to be less confident about their own skills in

using computers and, as a result perhaps, more sceptical about their value in using such technology effectively to help their pupils to learn. They may also have older computers and software that are not in accord with their views on appropriate activities for the children they are teaching.

Other research discussed suggested that these findings may well apply more widely and that the process of change is a slow one. However, if activities which early years professionals accept as appropriate are introduced then these can be successfully integrated into early years settings. This in turn may support more positive beliefs about the use and integration of technology in professional practice. The influences surrounding the adoption of computers can helpfully be divided into the three levels previously described at macro, meso, and micro levels. It is only when the micro level issues are taken into account that effective change is likely to take place. In the project described the teacher has not used the school's computer room before the project, but continued to use it after the research had finished. Individuals are relatively robust at resisting macro and meso level influences.

The results from the action research project previously described (and 11 similar projects which were also part of the research: see Moseley et al., 1999, p. 35) suggested that taking teachers' beliefs and educational goals into account and identifying developmentally appropriate activities using computers can support them in adopting new teaching approaches using computers. The authors further believe that an important component in this process was information about pupils' progress so beliefs about effective practices generally and about the effective use of ICT in particular are grounded in the impact that such beliefs and practices have on pupils' learning. Opinions about the effective use of computers in early years settings need to be backed up by information about what children are learning so the underlying values of those involved can be taken into account in interpreting the evidence about the effectiveness of computers in early years settings. Speculation about what works and why needs to be backed up with evidence and an understanding of the importance of the way in which teachers' educational beliefs and values help to make particular approaches effective.

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