UNIVERSITY OF SOUTHERN QUEENSLAND

Interactive multimedia problem-based learning for enhancing pre-service teachers' self-efficacy beliefs about teaching with computers: Design, development and evaluation

A Dissertation submitted by

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Abstract

Research has suggested that, despite support through policy and resource provision, information and communications technologies (ICTs) have made little impact on the practice of education and that limited teacher preparation for the use of ICTs represents a partial explanation. The purpose of this study was to investigate what form of professional education might be effective in preparing pre-service teachers to integrate ICTs into their teaching. Self-efficacy beliefs about teaching with computers were identified as a potentially significant source of influence on teachers' use of ICTs for teaching. It was proposed that interactive multimedia using a problem-based learning design (IMM-PBL) should be an effective tool for increasing self-efficacy. Principles for the design of IMM-PBL were derived from the relevant literature.

An IMM-PBL package was designed and developed for delivery in a web browser format using content relevant to the integration of ICTs into teaching. Interviews with and sample responses prepared by computer-using teachers provided the basis for ensuring the relevance of content.

The completed materials were evaluated in use with a group of 24 final year pre-service teachers in a Queensland university. Participants in the trials reported that the materials were engaging and assisted their learning about integrating computers in their teaching. A statistically significant increase in self-efficacy for teaching with computers was found for users who had initially low self-efficacy for teaching with computers.

The principles proposed for IMM-PBL design were found to offer a practical basis for the development of effective learning materials. With further development, IMM-PBL promises to be a powerful and flexible approach to supporting learning for teachers and other professionals.

Certification of Dissertation

I certify that the ideas, experimental work, results, analyses, software and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

Signature of Candidate

Date

Endorsement

Signature of Supervisors

Date

Acknowledgments

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Dedication

To my grandchildren

Emily, Joel and Samuel,

who have no memory of life without computers and the Internet.

May their teachers share their confidence for working with the new technologies.

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Chapter 1: Background to the research problem

Computers and associated technologies have been said to represent an "information revolution" comparable to the revolutions which followed the invention of the alphabet and the printing press (Spender, 1994). The physical presence of computers pervades the modern world of business and entertainment. Their impact on the collective psyche was evident in the widespread concern about the Y2K bug.

Yet, despite the manifest impact of computers elsewhere in society, there have long been suggestions that their potential for education has been largely unrealised. Whereas technology, including computers, would have rendered common practices of many occupations in the late twentieth century incomprehensible to practitioners from the previous century, education appears to be fundamentally unchanged (Papert, 1993). Anecdotal reports from schools confirm that computers, despite being almost universally available, are sometimes little used. A recent Queensland report, prepared within the Government department responsible for education, painted this picture:

> Since the late 1980s there have been "back to back" learning technology initiatives in Queensland state schools. While there has been a steady increase in the number of computers and peripherals used for learning, the application of computers to the teaching/learning process is best described as patchy. World's best practice is occurring in many classrooms, and, more rarely, at the whole school level, but in general computers are used in a supplementary and ad hoc fashion with little impact on student learning outcomes. (Galligan, Buchanan, & Muller, 1999, p. 1)

Acceptance that computers have a place in education is almost universal, even among those who express concerns about the ideological dimensions of educational computing. Bowers (1988) argued for teachers accepting responsibility for helping students to become critically reflective about the impact of technology on culture and Chandler (1990) conceded the effectiveness of computers for certain educational tasks but warned of the need for teachers to be aware of the underlying ideologies of computer software.

The use of computers in schools has been promoted for a variety of reasons, including community expectations and the desire to prepare students for an increasingly computerised workforce. For some years there was doubt about the direct benefits of computers for teaching and learning other than about computers. Now there is clear evidence that, when used appropriately, information and communications technologies have positive effects for student achievement, attitudes and classroom interaction (Galligan et al., 1999).

In brief, there is evidence that computers can provide benefits to education, broad acceptance that they should be used in schools, and official support for both the supply and use of computers in schools. However, the application of computers to teaching and learning is "best described as patchy" (Galligan et al., 1999, p.1) and it appears that many students are not yet experiencing the educational benefits of computers.

What are the barriers to more extensive and effective use of computers in schools? What might be done to reduce the effects of those barriers? These questions provide the starting point for this investigation.

1.1 Clarification of terminology and context

Before proceeding to consider these questions it is appropriate to clarify some of the key terminology which will be employed and to establish the context within which the issues will be examined.

1.1.1 Terminology

As computer technologies have evolved over the past couple of decades, so have the terms used in speaking and writing about their uses in education. It would not be possible to write a document of this type without making reference to computer hardware and software and using terminology which may have varied from time to time and place to place. Sometimes the various terms are interchangeable and sometimes not. For this reason, where reference is made to published materials, the original usage of the sources is preserved wherever it is possible to do so without losing the sense of the material. The following comments are offered, not as definitions, but for the general guidance of the reader.

1.1.1.1 Computer, information technology and related terms

The first educational uses of computers occurred when the only computers available were large centralised mainframe systems. Hence as smaller systems, first mini-computers and then personal computers, appeared in classrooms, some writers felt the need to distinguish these from mainframe computers. Personal computers were sometimes referred to as microcomputers in deference to the microprocessors around which they were built. Nowadays it can be safely assumed that, unless there is some indication to the contrary, reference to a computer in education means a personal computer running one of the common operating systems. That usage is generally understood, even internationally. However, regional variations in associated terms abound and may occasionally cause confusion for the reader unfamiliar with the context.

In the USA it appears to be quite common to refer to *technology* and mean *computer* or some associated technology. The International Society for Technology in Education (ISTE) appears to focus almost solely on computers. ISTE publishes a journal named *Learning & Leading with Technology* which rarely considers other than computer related technologies. ISTE also publishes the *Journal of Research on Computing in Education* which features articles that tend to conflate “technology” and “computer”. For example, an article titled *Examining teachers’ beliefs about the role of technology in the elementary classroom* (Ertmer, Addison, Lane, Ross, & Woods, 1999) refers exclusively to computer related technologies. The Association for the

Advancement of Computing in Education has a subgroup, the Society for Information Technology and Teacher Education, which publishes the *Journal of Technology and Teacher Education*. That journal also publishes articles with titles such as *Attitudes of preservice teachers about using technology in teaching* (Laffey & Musser, 1998) in which "technology" refers exclusively to computer related technologies. Hence, for most material published in the USA the use of *technology* can be assumed to mean *computer* unless it is clear that some other usage is intended. Recently there appears to have been a tendency to use *information technology* (Moursund & Bielefeldt, 1999) which has the benefit of being more explicit but it remains to be seen how widely the trend is followed.

In the UK, at least in recent years, there appears to have been standardisation on the term *Information and Communications Technology* (ICT) (Department for Education and Employment, 1998). Prior to that, the common usage appeared to be *information technology* (Twining, 1995) and before that reference was typically to *computers* (Dunn & Ridgway, 1991a).

In Queensland (and Australia) it has been common to refer to *computers* or *information technology*. The use of *technology* in place of either of those terms has been deprecated by the Australian Council for Computers in Education and the Technology Education Federation of Australia because of the potential for confusion with other aspects of technology in the school curriculum (ACCE, 1999). The term *learning technology* has been used in Queensland since 1994 (Queensland Department of Education, 1994) and it is gaining some currency at the national level (ACCE, 1999) although there appears to be support also for the use of *information and communications technology* (Gibson & Albion, 1996; Moran, Thompson, & Arthur, 1999). There are also occasional alternative usages such as *new technologies* (Galligan et al., 1999) or *communications and information technology* (Richards & Nason, 1999).

Of the terms considered, *information and communications technology*, abbreviated as ICT, should probably be preferred. It has wider international currency than any of the alternatives and is unlikely to be misunderstood even where it is not in common use. Its major disadvantage is the length of the description where use of the acronym is not appropriate. Within this thesis, the use of *computer* will be assumed to include associated technologies unless an alternative meaning is made clear by the context or otherwise. The terms ICT and computer will be used interchangeably unless clarity of expression demands otherwise.

1.1.1.2 (Interactive) multimedia, hypermedia and hypertext

According to Phillips and Jenkins (1997), *interactive multimedia* (IMM) describes computer software that primarily deals with the delivery of information. *Multimedia* refers to the inclusion of some or all of text, pictures, sound, animation and video within a coherent program. *Interactive* refers to the possibility of user control, usually by means of a computer. Interactivity is so much a part of current implementations of multimedia that any reference to multimedia can be assumed to be referring to IMM unless an alternative meaning is made explicit.

Hypertext is a way of constructing computer-supported, non-linear writing. It is "the ability to link any place in text stored in a computer with any other place in the same or different texts, that permits rapid access through buttons and other tools across non-linear pathways" (Horn, 1989, p. 6). The links in the hypertext information web are analogous to associations in human memory.

Hypermedia is "an extension of the idea of hypertext that incorporates other components such as video, illustrations, diagrams, voice and animation, and computer graphics. Typically an author creates computer-supported links between text, graphs, diagrams, photographs, video, music, film and other media" (Horn, 1989, p. 18).

Multimedia and hypermedia are not synonymous (Tolhurst, 1995). It is possible to create multimedia presentations, even interactive ones, which are essentially linear and do not provide for the richly interconnected web of information which is characteristic of hypermedia.

1.1.2 Context

Globalisation is a frequent theme of articles in the popular media. Although much of the discussion of globalisation centres on economic opportunities and effects there are many other aspects of life which are subject to its effects. Among the most obvious are media such as music, film and television.

The educational application of information and communications technologies is another field in which the principal trends appear to be taking shape internationally rather than within national or regional borders. This is hardly surprising given that the design of computer hardware and operating system software is dominated by a few companies and that the Internet makes access to information from and communication with colleagues in other countries virtually instantaneous.

It is true that there are some differences in the terminology used in different parts of the English speaking world to describe the technologies. It is also true that there are significant national differences in the structure and governance of schooling and in the curriculum. However, in reading the English language literature related to educational use of ICTs it quickly becomes evident that many of the issues, including those associated with teacher education, are not confined within national boundaries. International conferences such as the World Conference on Computers in Education and the annual conference of the Society for Information Technology in Teacher Education bring together delegates from many parts of the world who find that the issues they face are very similar.

In a field that is influenced by rapidly changing technologies, the existence of such common ground and the capacity for rapid communication of new developments is important because it enables greater benefits to be obtained from the results of research conducted in other places. Although some interpretation may be required before application of findings in new settings, most research on the educational applications of ICTs appears to be applicable internationally.

Thus, although the research described herein has been conducted in Queensland and will be most clearly relevant in that context, it is informed by the findings of research conducted in other parts of the world especially in the USA and UK. Moreover, it is likely that the findings will be generally applicable in other places.

1.2 Possible barriers to teaching with computers

Probably the first official recognition of computers in the Queensland school curriculum was in the 1974 revision of the senior secondary school mathematics syllabus which introduced units of work that included computer awareness and programming. Few schools had direct access to computers. Programming was typically taught by means of punched or marked cards that were dispatched to a remote computer centre for execution. Fortunate students, whose cards were correctly prepared, received printed output from their programs a few days later.

In the late 1970s some schools began to acquire early model Apple, Tandy and Commodore computers. These were predominantly local initiatives, promoted by enthusiastic teachers and funded by parent committees. For the first few years of the 1980s the number of computers in Queensland schools was small enough that an annual report listing them and describing their uses could be published. At that time there was little software, educational or not, available off the shelf. Computer education focused on teaching about computers and typically involved programming and other overtly technical aspects of computing. If the use of computers for teaching other content was considered at all, then it was usually in terms of simple tutorial or drill and practice software coded by teachers to their own design or using published program listings. Gradually, as basic applications such as word processors, databases and spreadsheets became available, the more creative or adventurous teachers found ways to use them to support teaching and learning *with*, rather than *about*, computers.

Barriers to the extensive and effective use of computers in schools might arise in several ways. One potential barrier might be the failure of policy makers to identify and promote appropriate developments in the educational use of computers. Assuming a supportive policy environment, another potential barrier to success might be failure to provide a sufficient level of computer resources to implement the policy. These represent logical points from which to begin an investigation.

1.2.1 The policy environment for teaching with computers

Queensland education policies have progressively recognised the importance of computing. Initially policy positions tended to focus on the value of technological skills for future employment. However, there has been a gradual development towards recognising the benefits that integration of computers in education may provide across a broad range of educational objectives.

The first Queensland policy on computers in education was the *Computers in the Curriculum Policy Statement No 1* which was issued in 1983 (Galligan et al., 1999). Its focus was on computer awareness, basic skills, computer assisted learning and vocationally oriented programs. It was followed in 1985 to 1987 with funding to support computer literacy projects in secondary schools.

In 1989, skills in information processing and computing were included in a national list of common and agreed goals for schooling (Australian Education Council, 1989). From 1989 to 1991, the Queensland government provided funding for Business Education Centres in all secondary schools and Electronic Learning Centres in 150 primary and secondary classrooms (Galligan et al., 1999). Although the Business Education Centres had a clear relationship to vocational education, the Electronic Learning Centres supported integration of computers in fields as diverse as art, music and social sciences.

In 1991 the effect of rapid technological change on learning and teaching was identified as one of eleven key issues for Queensland education and the integration of information technology for learning and teaching was identified as one of four goals for schooling (Queensland Department of Education, 1991). From 1992 to 1997 there was an initiative to fund computers for the upper years (six and seven) of primary schooling with a target ratio of one computer for every ten students.

It was more than ten years from the 1983 statement until there was another formal statement of policy in relation to computers in education. That came with the release of the *Computers in Learning Policy and Guidelines* (Queensland Department of Education, 1994). In contrast to the vocational emphasis of the 1983 policy, this document emphasised the use of computers to support learning across the curriculum at all year levels, although it also acknowledged the importance of computer skills for future entry into the workforce.

The most recent initiative, *Schooling 2001* (Education Queensland, 1998b), has set system-wide targets to be achieved by 2001. These include the provision of one computer for every 7.5 students, the connection of every classroom to the Internet, and the use of computers "in all key learning areas, P-12". At the same time, minimum standards for teachers in the use of learning technology have been set for achievement by 2001 (Education Queensland, 1998a).

Queensland schools have been set the dual goals of ensuring that students completing their schooling possess relevant vocational computing skills and that information and communications technologies are used to support teaching and learning across the curriculum. These goals are framed in documents that include commitments to providing the necessary level of resources.

Similar policy environments that recognise the potential contributions of ICTs to learning exist in the various Australian states (Moran et al., 1999), in the UK (Department for Education and Employment, 1998), and in the USA (CEO Forum, 1999). However, in every case there is concern that the potential is not being realised. If the barrier is not in the policy environment, then perhaps it is in the availability of computing resources.

1.2.2 Resources for teaching with computers

Computers are an accepted part of modern life. They are used almost universally in business and, in many countries, they are becoming increasingly common in homes. The Australian Bureau of Statistics (1999) reported that 35.4% of Australian households frequently used a computer at home. This rate rose to 58.7% for households comprising a married couple with children. About 25% of the adult Australian population accessed the Internet from any site in the 12 months to March 1998. As access to computers has increased in the wider community so has the expectation that computers will be used in schools as they are elsewhere.

Over the past two decades computers have become increasingly available in schools throughout the industrialised world. Cuban provided some indicative statistics for schools in the USA:

> In 1981, 18 percent of schools had computers; in 1991, 98 percent had them.
>
> In 1981, 16 percent of schools used computers for instructional purposes; by 1991, 98 percent did so.
>
> In 1981, there were, on average, 125 students per computer; in 1991, there were 18.
>
> In 1985, students used computers in school labs just over 3 hours a day; in 1989, that figure had risen to 4 hours a day. (Cuban, 1993, p. 186)

The trends evident in these statistics have continued. Recent data from the USA revealed ratios of one instructional computer per 5.7 students, one instructional multimedia computer per 9.8 students and one Internet connected computer per 13.6 students (Resnick, 1999). Students in elementary schools were likely to be able to access computers in both classroom (84% of students) and laboratory (79%). In secondary schools students were much more likely to be able to access laboratory computers (91% of students) than classroom computers (47%).

Although the detail might differ, similar trends have been evident in Australia. By 1992, more than 80% of primary schools in a sample taken across six regions in three Australian states had computers deployed in classrooms (Fowler, 1992). Student teachers returning from practicum reported that most of their supervising teachers had access to computers but that they had not observed the use of computers during their time in schools (Russell, 1992). In 1993, a sample of 245 Australian secondary schools was found to have a median student-computer ratio of 12 to 1 (Roberts & Albion, 1993). From a sample of 170 final year student teachers on practicum in Queensland primary schools, 75% reported that there was at least one computer available in the classroom where they worked (Albion, 1996b). More recently, from a sample of student teachers working in 33 primary schools in and around Melbourne, it was found that 64% of the schools provided computers in classrooms and 57% had a computer laboratory (Jones, 1998).

Provision of computers in schools is affected by many factors including the availability of funding. A relatively small proportion of schools has adopted a policy whereby each student has a personal laptop computer (Albion, 1999b). Although the majority of such schools are privately operated, a small number of government schools have developed laptop programs. These programs appear to be based on the assumption that the benefits of computers for teaching and learning increase in proportion to the availability of computers and can be maximised by having one computer for each student. One writer has suggested that, in order to ensure access to computers whenever they are needed, in addition to personal laptops for students and teachers, schools should have more powerful computers for specialised tasks resulting in a preferred ratio of about 1.5 computers for each student (Moursund, 1996). Although this might eventuate in the future, a review of the relevant literature suggests that the benefits being claimed for laptop programs are very similar to those reported for the use of desktop computers at more modest ratios of around one computer for three or four students (Albion, 1999b). It seems inevitable that, as computer technology advances, schools will eventually have access to abundant, affordable computers but there do not currently appear to be compelling reasons for pursuing a 1:1 ratio of computers to students at the expense of other educational resources.

Many of the early efforts to provide computers for teaching in Queensland schools depended upon the local support of schools, parents and communities. However, there is evidence of commitment by Queensland governments to the provision of computers for use by teachers and students at all levels in schools (Galligan et al., 1999). The first Queensland government initiative in 1985 provided computer laboratories in secondary schools for the purpose of teaching computer literacy. Because the project provided for a laboratory of 30 or 15 computers depending upon school enrolment the computer to student ratio varied. During the 1992 to 1997 period, the first broad initiative for primary schools sought to provide computers for Years Six and Seven at the rate of one computer for every ten students.

In 1997 the *Schooling 2001* initiative set systemic targets of one computer for every 7.5 students to be used "in all key learning areas, P-12" (Education Queensland, 1998b). Although the systemic target of one computer per 7.5 students is expected to be met by 2001 as an average across all schools, hundreds of individual schools will not attain the target (Galligan et al., 1999). Reasons include rapid growth, limited access to local funds and past decisions about priorities allocated to learning technology. The same document noted that targets in other Australian states ranged from one computer for eleven students in New South Wales by 1999 to one computer to five students in Victoria by 2000. It recommended that consideration be given to setting a new Queensland target of one computer for five students by 2005.

The combination of community expectations, educational policy and government funding has resulted in it being reasonable to assume that teachers and students in Queensland schools typically have some access to computers for support of teaching and learning. Similar conditions exist elsewhere, with the differences being in degree rather than kind. For example, there may be local variations in the ratio of students to computers or the capabilities of the computers, but teachers and students in most industrialised countries will have some access to computers for teaching and learning.

If the barriers to achieving the potential of computers for teaching and learning are not in the policy environment nor in the simple availability of computing, then where might they be? There may be answers to be found by examining patterns in the use of computers in schools.

1.2.3 Are teachers teaching with computers?

Papert has been a consistent advocate for the educational use of computers and was the prime mover behind the introduction of Logo as a medium for children working with the computer. However, he has expressed disappointment at the lack of impact of computers on education by comparison with their effects on other professions. He has likened the creation of computer laboratories in schools to the response that a living body makes to a foreign object such as a splinter by attempting to seal it off from the rest of the organism (1993).

Papert's view that the introduction of computers has had less than the anticipated impact on the day to day activity of education has been supported by research. Much of the research has been conducted in the USA but comparisons with Australian data where it is available suggest that the overall picture is similar.

Results obtained from broadly based survey research conducted by the International Association for the Evaluation of Educational Achievement (IEA) in 20 countries between 1987 and 1990 suggested that only relatively small proportions of teachers were active users of computers in their teaching (Plomp & Pelgrum, 1993). Among a group of eight industrialised countries the availability of computers for instructional purposes in lower secondary schools ranged from 36% of schools (Japan) to 100% of schools (USA) with each of the others recording over 70% availability. In each case more than half of the computers were located in "computer rooms" and for all but the USA (30%) and France (27%) the proportion located in classrooms was less than 20%. General purpose and subject specific software was widely available in the survey schools. However, the proportion of teachers who used computers in common subjects such as science, mathematics and the mother tongue was 15% or lower except for mathematics in Switzerland (21%) and for each of these subjects in the USA (> 40%).

Becker (1994) reported in more detail about the USA data collected in the IEA study described above. The sample included elementary, middle and high schools (1400 in all) in which surveys were completed by the principal, the computer coordinator and a sample of computer-using and non-computer-using teachers. Only one secondary teacher in six used computers in a substantial way. At the elementary level, most teachers reported students using computers in their classes but, with only one or two computers available in a majority of cases, the experience of individual students was necessarily limited. Moreover, the majority of teachers focussed their goals for computer use on basic skills rather than higher order thinking.

The second phase of the IEA study was conducted in 1992 and found that computers in schools were still used mainly for learning about computers although there was some increase in use across the curriculum (Pelgrum, Janssen Reinen, & Plomp, 1993). Responses from students in 17 different samples taken across countries and levels of education indicated that in no case did more than 30% of the students report having used the computer more than 10 times for a particular curriculum area in a year. In the vast majority of cases the proportion was less than 10%. In elementary schools (Japan, Netherlands and USA) the most common use was for playing games, followed by drill and practice, learning new material and word processing. In secondary education the most regular use was for programming or word processing followed by learning new material or drill and practice. Games were also widely reported as a significant use.

Again, Becker (1998) reported additional insights about the USA data gathered in the 1992 IEA study. He noted that the data suggested that the typical student had between 40 and 120 minutes of computer access per week, that the patterns of use indicated a focus on practice of routine skills rather than higher level problem solving and that between 1989 and 1992 there was a decline in computer programming instruction and an increase in the use of word processing. Most of the word processing activity appeared to be undertaken in computer education or business education classes but increasing numbers of English and language arts teachers reported students using word processing for assignments as an individual option rather than as part of systematic instructional practice. He suggested that more widespread use of computers as productivity tools was restricted by teachers' priorities among competing instructional objectives, and limited time and computer resources.

In another study which surveyed a sample of 1200 USA teachers who had been nominated as worthy of recognition for their efforts at using technology, Hadley and Sheingold (1993) received returns from 608 participants who were in 576 different schools across the USA. The teachers who responded were mature and experienced and included a greater proportion of males than were in the teaching population as a whole. A wide variety of computer-based practices were reported, although, as in the IEA studies, word processing, drill and practice, tutorial programs and games were widely used.

Marcinkiewicz (1994a) reported on a smaller scale study of computer use by teachers from four elementary schools in the eastern USA selected according to criteria which ensured that computers had been available for use in teaching for at least three years. Of 149 teachers (116 females), 45% did not use computers at all for teaching and a further 47% used computers in ways that were not of critical importance to their teaching. Marcinkiewicz concluded that teachers were under-utilising the computers available in their schools.

Australia did not participate in the IEA study and there are no comparable data for a sample of schools or teachers with equivalent coverage to that found in the IEA studies. Sherwood (1993) replicated the work of Hadley and Sheingold (1993) in Australia during 1992. Of 731 teachers who were surveyed following their nomination as "experienced and effective users of computer technology in the classroom", 362 responded. As in the USA study they were mature and experienced. The most common application in use was word processing but significant numbers also reported using drill and practice software, adventure games, simulations and problem solving programs and tutorial and paint programs. No indication of frequency of use was reported.

Roberts and Albion (1993) reported that a sample of computer coordinators in Australian secondary schools characterised approximately 40% of the teachers in their schools as making "no use of computers" and just 20% as "regular and effective users". Other than for teaching about computers, the most common use of computers in the curriculum was in the teaching of English, and word processing was the most commonly used application.

An international survey of IT use in education was undertaken in 25 countries (not including Australia) between November 1998 and February 1999 (International Association for the Evaluation of Educational Achievement, 1999). It found that the availability of computers for instruction was continuing to rise and had reached an average of one computer for ten students in many of the countries. Many schools in the developed countries had Internet access but its use by students was still low. There were indications that ICTs facilitate changes in pedagogical practices towards student-centred approaches but adequate training of teachers was still a major problem in most countries.

Data from a recent large scale survey in the USA (Resnick, 1999) confirmed the impression that some teachers are adapting their approaches to integrate technology but that there are many teachers who have yet to adopt technology. In 54% of schools over half of the teachers used the Internet for instruction and in 69% of schools at least half of the teachers used a computer daily for planning and/or teaching. However, 55% of fourth grade students and 34% of eighth grade students reported that they "never or hardly ever" used a computer for school work. Fewer than 20% of students reported that their language arts teachers had them "use a computer to write drafts or final versions of stories or reports" more often than one or twice a month.

When these results are compared to those from the IEA study (Pelgrum et al., 1993), it is clear that there has been some increase in the use of computers for teaching. However, it is by no means clear that the level of use of computers for teaching and learning is commensurate with the investment of public funds.

During 1998 an evaluation was conducted of the 1993 to 1997 program to provide computers to government primary schools in Queensland (Galligan et al., 1999). Most schools achieved the target ratio of one computer per ten students in the upper two years of primary school. The results for computer use were mixed with just 20% of schools providing strong evidence of computers being used as tools for teaching and learning. Significant integration occurred in only two subject areas, English and technology, although there was more limited evidence of computer use in science, mathematics and the arts.

In Queensland, as in other developed economies (International Association for the Evaluation of Educational Achievement, 1999), most teachers now work in settings where the prevailing policies actively encourage them to integrate computers. Most teachers have access to computers that could be used for teaching and learning. Nevertheless, it seems that relatively few teachers have adapted their practice to make computers an integral component of the teaching and learning environments in their classrooms.

In an interesting metaphor, teachers' experience of the Internet has been compared to that of people who become involved in a different country (Williams & McKeown, 1996). A common first experience is that of a tourist who seldom achieves more than a superficial appreciation of the country they visit. Immigrants may be uncomfortable at first but eventually begin to feel at home. Natives are born in a country and are typically well adapted. In applying this metaphor to people's experience of the Internet, it has been suggested that the distinction falls along age lines with those under 25 being closer to natives in the new technological world (Bigum & Lankshear, 1998). Could it be that the failure of computers to have their anticipated impact on schooling is a generational phenomenon? Will the barriers go down and computers be more often integrated into teaching as the new generation of teachers, natives in the new technological landscape, take their place in the classroom?

1.2.4 Teaching with computers – the next generation

It is tempting to look to the next generation of teachers as the best hope for widespread use of computers for teaching. Information technology has become widely accessible in homes, schools and other places over the past couple of decades. Hence it seems reasonable to expect that mostly younger, newly graduating teachers will be more comfortable with computers and that they will be less likely to have committed themselves to teaching practices that do not readily support computer use.

Two areas of research offer insights into the validity of these expectations. One relates to the knowledge of and attitudes towards computers that student teachers bring with them or develop in the course of their teacher education program. The second relates to the use made of computers by student teachers during teaching practice or by beginning teachers on their first appointment. The research outlined below does not inspire confidence that newly graduating teachers will necessarily be more likely to teach with computers than their more senior colleagues.

Research in the area of student teachers' knowledge of and attitudes towards computers has been conducted in various contexts over the past decade or so. In studies conducted in the UK during 1987 and 1988 (Summers, 1988, 1990), a substantial minority of students (34% to 43%) admitted to negative feelings about computers. The majority had little or no experience of computer use but generally agreed that knowledge of computers was important for teachers. A comparative study conducted in Australia during 1989 yielded generally similar results (Wilson, 1990) although only 24% of students in that study reported negative feelings about computers.

These studies were conducted at a time when the student teachers who progressed directly from secondary schooling to teacher preparation would have been in secondary schools during the mid to late 1980s. At that time, although many secondary schools in the UK and Australia would have had computers the numbers were small and access was limited. If this is a reasonable explanation for the limited computer experience and lack of knowledge evident among student teachers, then it might be expected that student teachers' knowledge and experience of computers would have increased over time.

In a longitudinal study of computer literacy skills among students entering a US teacher education course between 1991 and 1997 (Sheffield, 1998), students were asked to rate themselves for several computer related skills. The scale ranged from 1 (no experience), to 3 (basic familiarity), to 5 (expert). A generally upward trend was observed from year to year especially for the use of the word processor and the mouse. However, the only category on which the mean rating in the final year exceeded 3 was for use of the mouse. The mean for word processing rose from 2.13 in 1991-92 to 2.89 in 1996-97 but mean ratings for databases and spreadsheets both remained below 2 for the duration of the study.

A study conducted during 1997 with 110 first year teacher education students in Australia (Albion, in press) collected self-report data on attitudes towards computers and confidence in using various types of software at the beginning of the course. On a scale from 1 to 4, the mean rating for usefulness of computers was toward the high end at 3.2 but the mean level of comfort was just above the half-way point at 2.5 and overall confidence for using computer applications returned a mean of 2.3. The latter value was a composite score across several applications among which the highest mean was 2.9 for word processing.

Based on these studies, it seems that student teachers regard computers as being somehow important and useful for their future careers. However, many of them appear to lack confidence in their own capacity to make effective use of computers. The implication appears to be that it would be unwise to rely upon the computer skills that students bring to a teacher education course as the sole basis for their use of computers in teaching.

Research on the use of computers by student teachers during practicum or by beginning teachers has also been conducted over the same period. An observational study conducted in Texas with student teachers who had completed a required computer literacy course (Diem, 1989) found that, although the students had adequate technological knowledge, lack of attention to computer use in methods courses had left them unable to effectively integrate computers into their subject areas. Moreover, their supervising teachers in the schools did not generally use computers or encourage the student teachers to do so. Where students did use computers in teaching it was mostly restricted to low level applications such as drill and practice although several student teachers of English were able to use word processors for writing skill development.

In a study which used ethnographic methods to explore and describe use of computers in the classroom by beginning elementary teachers in south-eastern Michigan, those uses were found to be quite limited (Novak & Knowles, 1991). Especially in the first year, the beginning teachers' available time was consumed by the routine tasks of teaching and the use of computers was an extra which, although they saw it as important, was of lower priority than more basic activities. When the computer was used, it was often as a sort of electronic workbook. During the second year there was some development in uses such as word processing but the workbook view continued to dominate. The authors concluded that the beginning teachers had few examples of exemplary computer use upon which to draw and that teacher education programs could do more through modelling of computer use and provision of field experiences which included computer use. Restricted computer use by these beginning teachers despite their stated desire to use it may have been, as they claimed, the result of other pressures on their time but might also be related to the professional environment in which they found themselves.

Dunn and Ridgway (1991a; 1991b) examined the use of computers during initial and final teaching practice sessions for the same cohort of 103 student teachers in the UK. The proportion of students using computers for teaching increased from 45% in the initial practice to 71% on the final practice, with almost 80% of the latter qualifying as more than token usage. However, the researchers considered this unacceptably low because 12% of the responding students would graduate with no experience of using computers with children and the experience of those who had used computers was generally limited to a narrow range of applications. In an Australian study, Downes (1993) investigated use of computers in practice teaching at three different stages of a course. Although there were significant increases in the frequency of use later in the course, there were still fewer than 50% of student teachers using computers in their final practice teaching session. The most significant factor influencing student teachers' use of computers with children was found to be the supervising teachers' use of computers with children.

In a study conducted at the University of Southern Queensland (Albion, 1996b), 75% of 107 students on their final teaching practice reported that there was a computer in the classroom where they worked but only 50% of those with a computer in their classroom used it for teaching. This was despite 90% having rated the computer as having some or a great deal of potential usefulness for primary education. Oliver (1993) reported on a study in which beginning teachers judged themselves to make substantially less use of computers in their teaching than other teachers in the same schools. A recent Australian study of students on teaching practice (Jones, 1998) found that only 18% used some form of learning technology daily and 42% used it only once during the four week experience. This was despite their supervising teachers having been specifically requested to encourage students to use computers and to provide role models by demonstrating their own use of technology.

On the basis of this evidence, the solution to realising the educational potential of ICTs does not appear to lie in simply waiting for a generational change in the teaching workforce. Pre-service and beginning teachers do not appear to use computers significantly more than their more experienced colleagues. In fact, some studies (Hadley & Sheingold, 1993; Oliver, 1993; Sherwood, 1993) have found that more experienced teachers are more likely to be successfully integrating computers into their teaching. If simply waiting is not the answer, then a solution must be sought elsewhere.

The review of the Queensland project for funding computers in primary schools found that the reasons for restricted integration of computers in the curriculum were linked to limited professional development being available for teachers (Galligan et al., 1999). Although schools were permitted to spend up to 20% of the grants on teacher professional development, only 2% of the total expended over 5 years was used for this purpose. The reluctance to divert funds from the purchase of hardware to develop the capacity to use it effectively is a serious obstacle to the effective integration of computers into teaching.

In an editorial comment on a collection of papers in the *Journal of Information Technology in Teacher Education*, Collis (1993) noted that in many of the papers a focus on the teacher rather than the student emerged as a "reflection of the centrality of the teacher in the school-IT use environment" and suggested that a "focus on teacher change rather than student outcomes is a reasonable choice for teacher-education strategists" (p. 124) seeking to improve the effectiveness of learning and teaching with computers. It appears that the solution to improving educational opportunities for students in the schools may lie in first improving opportunities in teacher preparation courses and in professional development for practising teachers.

1.3 Professional education for teaching with computers: The problem to be investigated

The evidence summarised in the previous section suggests that teachers represent the major barrier to realising the educational potential of ICTs and that professional education of teachers provides the key to overcoming that barrier. Cogent arguments have been offered for alternative points of view (Bigum & Lankshear, 1998; Cuban, 1993, 1998; Hodas, 1993) which attribute the difficulties with integrating computers to the culture of school or to the constantly changing expectations visited upon teachers as information technology has evolved.

Those arguments have some force. However, for every voice raised in support of targeting school culture as a basis for increasing educational use of ICTs, there are numerous voices in support of programs to encourage teachers, through appropriate professional education, to adopt approaches which will lead to better integration of ICTs in classrooms. Thus, on the balance of probabilities, it seems reasonable to investigate the possibilities for developing programs of professional development that will assist teachers to adopt teaching approaches which appropriately integrate the use of ICTs.

Hence the overall direction of this study moves toward investigating what form of professional education might be successful in preparing teachers for teaching with computers. Because the study was located in a Faculty of Education with a substantial pre-service teacher education program and because prospective employers of graduates have expectations that beginning teachers will be adequately prepared for teaching with ICTs, the study is most appropriately directed towards pre-service education of teachers. Moreover, in order to arrive at useful conclusions about the effectiveness of any proposed solution the study would need to address design, development and evaluation of any proposed approach to professional education for integration of information technology.

Chapter 2: Literature review

As outlined in Chapter 1, the overall direction of this study is the investigation of what approach to professional education might be successful in preparing pre-service teachers for integrating information and communications technologies (ICTs) into their teaching.

There is no single body of research that encapsulates the knowledge upon which such a project could be based. As a consequence this review comprises a series of sections which deal with the several fields from which ideas have been drawn.

Several different methods were employed to locate and access relevant literature. Throughout the course of the research, periodic searches were conducted through the electronic version of the ERIC index and in EBSCOhost using search terms relevant to the various areas of interest. In addition, full text searches were conducted in electronic versions of the proceedings of the EDMEDIA (1996 to 1998) and SITE (1996 to 1999) conferences, the contents of new issues of several relevant journals were regularly scanned and searches of the World Wide Web were conducted using the AltaVista index. Citations in sources located through these searches provided a secondary source of relevant references. Although the literature search was probably not exhaustive it was a thorough search of the most relevant sources.

The order in which the major sections are presented in this review has been chosen to elucidate the logic underpinning the design of the multimedia materials which have been developed in this study. The review will begin by considering the research related to computer use by teachers in the expectation of identifying one or more key factors which influence teachers' behaviour relative to teaching with ICTs. It will consider what is known about teachers' use of computers and the factors which influence that use before turning to some studies about the preparation of teachers for computer use.

Because, as will become apparent in the course of the review, teachers' beliefs play a significant role in determining their approaches to the use of computers for teaching, the second major body of literature to be reviewed will be in the area of teachers' beliefs. Self-efficacy beliefs will be identified as particularly important influences on behaviour and the literature on self-efficacy as it relates to teaching and computer use will be reviewed. The section on beliefs will conclude by reviewing research related to changes in beliefs and the nature of the educational experiences that might result in the desired changes in beliefs about teaching with computers.

Both the research on computer-using teachers and self-efficacy theory point to the importance of models or exemplars as influences on teachers' use of computers. Literature related to case-based methods in teacher education is reviewed, especially in relation to its use as a basis for the design of multimedia materials.

Problem-based learning (PBL) is closely related to case-based instruction and is used extensively in the education of professionals. It will be argued that the research suggests a sufficiently good match between self-efficacy theory and problem-based learning to support the selection of PBL as the basis for design of the proposed multimedia package.

Because there appears to be no accepted model for the application of PBL to the design of interactive multimedia (IMM), the literature related to the design of constructivist learning environments is reviewed as the basis for developing guidelines for the design of IMM using PBL as the design framework (IMM-PBL). Research on interactivity in multimedia and related work on the use of narrative form in IMM design is also reviewed.

The chapter concludes with a statement of research-based principles for the design of IMM-PBL.

2.1 Investigations of computer-using teachers

Teachers' use of computers in their teaching varies and has been characterised as "patchy" (Galligan et al., 1999). Some teachers have made considerable progress towards integrating ICTs into their teaching but others have not. These differences may be influenced by characteristics of the teachers or of the environments in which they work. In either case, understanding how computer-using teachers and their circumstances are different should provide useful indications of what measures might be effective in preparing teachers to integrate ICTs.

This section will review the research about computer-using teachers. It will also consider some research into the effects of computer use on approaches to teaching before turning to a consideration of what research might reveal about educating computer-using teachers.

A search in the ERIC databases reveals a substantial volume of literature related to the use of computers by teachers in classrooms. Additional references were located in conference proceedings and in reference lists of already located papers. Much of the available literature is restricted to describing computer use in particular circumstances. There appear to have been few studies conducted on a large scale. All of the identified studies that either used large samples or tracked teacher behaviour over a substantial period are included in this review. Other studies describing computer use by practising or pre-service teachers were selected on the basis of their attempts to identify and explain patterns of behaviour or their direct relevance to the Australian scene. A further, smaller, set of studies attempts to identify ways of predicting teachers' use of computers and as many of these as were identified were included in the review.

2.1.1 Describing teachers' computer use

Published descriptions of computer-using teachers have been based on different approaches to research. One source is research based on surveys which have gathered data about teachers who were regarded as in some way exemplary in their use of computers for teaching. A second source is the long term study of teachers working in schools with increased levels of ICTs available for teaching. A third source is represented by the results from a number of smaller studies undertaken using predominantly qualitative methods. Finally, there are some studies which have looked specifically at the computer use of pre-service and beginning teachers. Findings from each of these groups of studies will be reviewed in turn.

There appear to be relatively few published studies in each of the first two groups. This might be explained by the difficulty of marshalling the resources to support either extensive surveys or longitudinal studies. The studies which were located for review were conducted as long ago as 1985 but, as noted in Chapter 1, many of the general trends relevant to computer use by teachers appear to be stable over that period of time. Moreover, as will be evident from this review, more recent though less extensive studies have returned results consistent with the surveys and longitudinal work reviewed here. The studies reviewed in these two categories were the most extensive and widely cited. The surveys were conducted nationally in the USA and one was replicated in Australia. The longitudinal work was conducted in the USA over a period of a decade from 1985.

With the exception of one study conducted in Australia, the qualitative studies in the third group were undertaken in the USA and Canada. The fourth group of studies of pre-service teachers are from the USA, UK and Australia. In each case the studies reviewed here are thought to represent the most significant findings in the field. As was argued in Chapter 1, teachers' responses to IT in education appear to be broadly similar internationally and the characteristics of computer-using teachers revealed by this research are likely to be relevant beyond their immediate locality.

2.1.1.1 Surveys of exemplary computer-using teachers

Hadley and Sheingold (1993) reported the results of a survey conducted in the USA during 1989. The study began by seeking nationwide nominations of "teachers who were known for their efforts in integrating computer technology into their teaching". Surveys were distributed to over 1200 teachers identified through this process and 608 responses were received from teachers in 576 different schools. The schools represented in the survey had substantially more access to technology than average schools and almost half of the teachers in the schools had used computers for instruction, many for periods ranging from four to ten years. The responding teachers were mature and experienced, with more than half between 40 and 49 years old and with 75% having been teachers for 13 years or more. Men were slightly over represented by comparison with the total population of teachers. As a group these teachers were very comfortable with computers and most (73%) had used computers in their teaching for five years or more when the data were collected in 1989. Given that personal computers were not widely available prior to 1980, these teachers were evidently strongly motivated to work with computers. Their motivation extended to investing their own time in learning about computers through a variety of means. Most (77%) reported that they had continued access to on-site support and advice from like-minded colleagues and consultants.

In the classrooms in which these teachers worked, computers were used as a multipurpose tool. The most commonly used software was the word processor and the most frequent approach to curriculum was for students to make their own products using software tools, often incorporating several different kinds of software.

As many as 88% of the teachers indicated that computers had made a difference to their teaching. Overall the changes included higher expectations for students' work, greater opportunity to support students working individually and independently and a change from teacher-centred to student-centred classrooms with the teacher acting more as a coach than as information dispenser.

According to Hadley and Sheingold (1993), the data showed discernible patterns in the evolution of teachers' practices with computers over time. Teachers with more years of experience using computers reported higher levels of comfort with computers, used more applications, were more likely to have students creating their own projects and were more likely to explain an idea or demonstrate a skill with the computer. As they gained experience, teachers tended to increase their use of word processors and databases and decreased their use of drill and practice software. The use of the computer for enrichment, remediation and drill declined slowly with years of experience. Overall the pattern appeared to be one in which teachers began with approaches that were similar to familiar practices like the use of printed workbooks and, as they gained experience, decreased these uses in favour of approaches that afforded more opportunity for self-generated learning by students.

For these teachers, the major incentives for incorporating computers into their teaching appeared to be related to expanding opportunities for students, increasing the effectiveness of teaching and personal satisfaction from professional growth. Overall they rated barriers to computer use as diminishing over time. The most significant barriers were reported as inadequate administrative support, routine problems with factors including time, space and access, lack of suitable software, difficulties in integrating computers with school system requirements, and limitations with hardware and support services.

In summarising their results, Hadley and Sheingold (1993) noted that the achievements of these teachers appeared to be the result of a combination of factors, namely, the teachers' own motivation and commitment, peer support for their efforts and access to technology. Multiple profiles of accomplishment emerged, suggesting that "integration of computers into classrooms is a local phenomenon that is highly influenced by the particular context" (p. 299) despite being influenced by the same key factors. The implication is that there is no simple formula for computer integration and that typically it may require five to six years for a teacher to adapt to teaching with computers. Hadley and Sheingold concluded by noting that the results of their research closely paralleled those obtained from small observational case studies but that they were unable to estimate the number of teachers who might display the characteristics they had identified.

Sherwood (1993) reported on an Australian survey conducted in 1992 and using the instrument from the Hadley and Sheingold (1993) study. Following a nomination process which sought names of teachers considered to be "experienced and effective users of computer technology in the classroom" (p. 169), surveys were sent to 731 teachers and 362 responses were received. As in the USA study, the respondents were mature and experienced, with 49% between 35 and 44 years old and 61% having been teachers for 13 years or more. Again, men were over represented in comparison to the population. About half of the teachers had used a computer in their teaching for more than seven years and 65% had a home computer. They had taken advantage of a variety of opportunities for learning how to use computers in their classrooms but almost 80% reported that they were to some degree self-taught. Although they were supported at school level they felt that support from the wider school system was inadequate.

As in the USA study, a large proportion (76%) of the teachers felt that the computer had made a significant difference to the way they taught. Similar changes to those in the USA were reported, namely, a move from teacher-centred to student-centred classrooms with more emphasis on individualised and independent work and higher expectations of students' performance.

The perceived incentives and barriers to computer use were also similar to those in the USA Rather than gains in personal financial rewards or status these teachers were motivated by the enhancement that computers could offer to students' learning and to their own professional satisfaction. The most common and significant barrier was limited access to computer hardware, followed by inadequate financial support. Other major barriers included lack of time to develop lessons that use computers and inadequate training with computers, especially as it relates to integrating computers into teaching.

Surveys of teachers selected for their notable use of computers in teaching (Hadley & Sheingold, 1993; Sherwood, 1993) have provided valuable data about exemplary teachers but they do not provide any basis for determining what proportion of teachers might fit into the exemplary category nor how they differ from other teachers. Using data collected from a broader sample of schools and teachers in the US component of the 1989 IEA survey (Pelgrum et al., 1993), Becker (1994) reported an analysis which sought to answer these questions. He began by defining a set of criteria similar to those used by Hadley and Sheingold to nominate their exemplary teachers and applied the criteria to data collected in the IEA survey. On that basis he determined that exemplary computer-using teachers represented about 5% of computer using teachers and about 3% of the overall teacher population including those who did not use computers at all.

When the data were examined for correlations of other variables with the presence of exemplary computer-using teachers, four characteristics seemed to increase the likelihood of exemplary computer users being present. These were presence of a social network of computer-using teachers in the same school, sustained use of computers at the school for consequential activities such as writing rather than drill and practice, resources for professional development and support staff, and provision of additional resources such as smaller class sizes or funds for software.

Becker's analysis revealed substantial personal differences between the exemplary computer-using teachers and the others. He characterised the two largest differences as "alterable", that is, capable of being changed by school or system initiatives. Firstly, exemplary computer-using teachers spent more than twice as much time working on computers at school but there were only small differences in home use which suggested that the difference was in opportunities for use at school rather than in personal interests. Secondly, exemplary computer-using teachers had more formal training in using and teaching with computers.

Other differences reported by Becker were in what he termed "general experience variables" (p. 309) which are not directly alterable but may provide indicators of characteristics which might be sought in recruits to teaching. Hadley and Sheingold (1993) concluded that at least five years of computer use was required for teachers to develop expertise. Becker found that exemplary users had, on average, taught for three years longer than the other computer users and had used computers for a year longer. On the basis of additional results, Becker concluded that experience alone was not sufficient but it did contribute. Differences in teachers' own educational backgrounds also appeared to contribute. A large proportion of exemplary users had more graduate credits and there were also differences in areas of undergraduate study. Becker suggested that the differences arose from greater interest in both subject matter and effective teaching and learning. Finally, although males comprised only a quarter of the other computer-using teachers, nearly half of the exemplary teachers were male. Even when the effects of other variables such as graduate education and time spent with computers were removed by multivariate analysis, the gender of a teacher was still a strong predictor of exemplary computer-use.

Becker also reported on some consequences for schools of having exemplary computer-using teachers on their staff. Exemplary users appeared to be more prepared to modify curriculum by downgrading some content in exchange for computer activities that permitted more in-depth concentration on other aspects of curriculum. They were not more likely than other computer-using teachers to individualise work for students but they did emphasise more small group work and gave students more flexibility in choice of software. Their frequent and central use of computers made it important that equipment was in good order and they reported more problems than other computer-using teachers. When asked how they would apply additional funding, they were less likely to want more hardware and software in the classroom and more likely to request a computer for use at home or additional inservice training.

2.1.1.2 Teachers in ICT-rich classrooms

Probably the most significant study of teachers working in ICT-rich settings was the Apple Classrooms of Tomorrow (ACOT) research project which was initiated in 1985 to observe the effects of "environments in which technology was used as routinely as paper and books" on teaching and learning (Apple Computer, 1995, p. 9). Initially, in order to ensure continuing access to computers, the ACOT project provided each teacher and student with two computers, for use in school and at home. In subsequent years the distribution of computers evolved to accommodate more students and classrooms with typical ratios of one computer to three to five students.

Researchers working with the ACOT project have reported changes occurring for students and teachers. Students' behaviour, attendance and performance all improved. At the beginning of the project, classrooms were characterised by teacher-centred forms of instruction entailing lectures, rote learning, and norm-referenced testing. When technology was used it was for seat work similar to familiar use of work sheets. As the project progressed, classrooms shifted towards more learner-centred modes involving collaboration among teachers and students, learning through inquiry rather than by rote, and assessment by criterion-referenced methods. Technology was increasingly used for communication, collaboration, information access and expression.

Student engagement was greater and lasted longer in classrooms where teachers used technology as one tool among many, integrated technology into the larger curricular framework, emphasised the use of tool applications and adjusted the use of technology according to individual differences (Sandholtz, Ringstaff, & Dwyer, 1994). Teachers were challenged to re-examine their beliefs about their tole in the classroom and to move from curriculum-centred instruction to child-centred practices and more active learning. In all of this the role of ongoing support was crucial.

Teachers' use of technology in the ACOT project appeared to evolve through an orderly succession of stages after computers were introduced into the classrooms (Dwyer, Ringstaff, & Sandholtz, 1990). In the *entry* stage teachers needed to learn the basics of the new technology and establish routines in the changed environment before progressing to the second, *adoption* stage in which technology was used to support traditional instruction. As computers were integrated into traditional practice, teachers moved into a stage of *adaptation* where they focused on increased student productivity and engagement using tools such as word processors. The fourth stage, *appropriation*, centred on project-based and interdisciplinary work where technology became one of several tools to be used as needed. As teachers reached the fifth and final stage of *invention*, they began to discover new uses for technological tools and developed projects that combined multiple technologies.

2.1.1.3 Other studies of computer-using teachers

The survey research provided a snapshot of teachers at the leading edge of computer use and the ACOT research demonstrated how teaching and learning may develop in ICT-rich settings. Other studies have been conducted on a smaller scale or over short periods in settings where it has been possible to observe both teachers who do and those who do not use computers.

Honey and Moeller (1990) reported the results of a study in which 20 teachers from elementary, middle and high schools in two New York school districts were interviewed about their teaching practices with a focus on the use of computers. The sample was selected to include both teachers who were using computers as an integral part of their teaching (11 teachers) and others who had similar opportunities to use computers but had not done so (9 teachers). All of the participants were experienced practitioners with the average teaching experience in each group being over 18 years. The interviews covered general classroom practices and objectives, the relationship between technology and education, technology in the classroom and classrooms of the future. On analysis of the data, four different patterns emerged. All eleven "high-tech" teachers formed a fairly homogeneous group who manifested student-centred pedagogical beliefs and had used technology to implement practices such as small group and project work in their classes. The "low-tech" teachers were characterised by three different orientations towards the use of computers. Three teachers shared the progressive educational practices of the "high-tech" group but were ambivalent about the use of technology. They expressed anxiety about computer use and had very limited experience which would persuade them of its usefulness in their teaching. Four teachers were characterised as exhibiting "traditional practices and technological refusal". For these teachers, the adoption of technology posed an apparent threat to their customary approaches to teaching. The final group of two teachers shared the progressive practices of the first two groups and, although they would have liked to use computers, either the equipment was not available or they had problems scheduling time in the computer laboratory. The implication appears to be that teachers who favour traditional classroom practices find more difficulty in embracing the use of new technologies in the classroom. However, for these teachers at least, although an orientation towards progressive practice appears to be a necessary condition for adoption of computers for teaching, it is not a sufficient one.

The decisions that teachers make about the application of computers in their teaching are likely to be consistent with their pedagogical beliefs and existing practice. Honey and Moeller's (1990) study points in this direction and there is confirmation in another study reported by MacArthur and Malouf (1991). This study entailed classroom observations, interviews and document analysis which resulted in a series of case study reports from which conclusions were drawn. A group of four special education teachers participated over a period of approximately three months. They were selected from a pool of potential participants on the basis that they had a minimum of two years experience using computers in a classroom and full-time access to a computer in their classes for the duration of the study. Overall the teachers' goals for the use of computers were consistent with their broader educational goals. Different emphases in the educational goals of the teachers influenced the ways in which they used computers. A teacher who emphasised self-esteem and social interaction focussed on the word processor for producing attractive final copies of written work, whereas a teacher interested in multisensory repetition as a learning method used the word processor to support repeated copying and editing. Each teacher attempted to fit computers into the regular organisational structures of their classroom and observed variations in computer use were consistent with their overall organisation. In general these teachers approached computers as a means of extending and enhancing existing approaches to teaching and learning in their classrooms. This preservation of known structures and procedures may have contributed to their success in introducing the new technology.

Nevertheless, there is some evidence for the use of computers having affected teachers' pedagogical styles. Swan and Mitrani (1993) observed 13 teachers in two high schools working with a total of 185 students in remedial classes for reading and mathematics. The methodology used paired observations of student-teacher interactions involving the same students, teachers, and content taught by computer-based and traditional instruction. They found that teaching and learning in computer-based classrooms was significantly more student-centred and individualised than teaching and learning in traditional classroom settings. The software used in the study was an Integrated Learning System (ILS) that was capable of delivering entire curriculum components and it might be argued that this would affect the style and content of teacher-student interactions. However, the authors claimed that the pedagogical styles of the teachers changed when they worked with the ILS to one that was more student-centred than the style they used in traditional classrooms. Given that the same teachers and students were observed in both environments there seems reason to believe that the use of computers made a difference by encouraging teachers to adopt different pedagogical styles.

Miller and Olson (1994) used a case study approach to examine claims that computers cause changes in the way that teachers teach. They provided a detailed description and analysis of one typical case drawn from a larger, three-year study of a Canadian K-6 school where computers were supplied at a ratio of one for every seven pupils. The authors identified clear connections between the traditional practices of the teacher with her first grade class and the ways in which she used database and word processing software in the class. In each case, the use made of computers was directly related to the teaching approaches the teacher had used prior to the availability of computers. Miller and Olson argued that teachers' prior practices and routines are a powerful influence on computer use and that teachers who are able to enhance and extend their conventional practice using computers may be better equipped to deal with any problems associated with the new technology than teachers who must adopt entirely new approaches.

Ethnographic research using observation and in-depth interviews has been used to go beyond the categorisation of behaviour obtained from survey research. Evans-Andris (1995) studied the computer use of 72 teachers in nine elementary schools where computers had been available for at least five years and were centralised in laboratories. She identified three computing styles among the participants. Approximately 60% of the teachers practised *avoidance* in which they provided access to computers for their students but made little use of the equipment themselves. They tended to teach *about*, rather than *with*, computers. About 28% of the teachers adopted *integration* as a style. They spent time mastering the equipment and organised classes so that technology was used as a tool for teaching. The remaining 8%

of the teachers adopted a style of *technical specialisation* which could be confused with *integration*. These teachers had strong computer skills and organised computer classes carefully but with a focus on teaching about computers which typically failed to engage the interest of students. These findings suggest that caution should be applied when interpreting the results of survey research on teachers' use of computers since the most gross aspects of behaviour, such as frequency of visits to computer laboratories, may tell less than the full truth about the educational benefits of the experience.

Newhouse (1998; 1999) studied the impact of student-owned portable computers in an Australian school over a three year period using both quantitative and qualitative methods. He found that apart from a few isolated combinations of teachers and classes there was little change in classrooms that could be attributed to the presence of computers. Few teachers implemented substantial computer use and most supported only a very limited role for the computers. The reasons appeared to be related to teachers' preferred pedagogy, their lack of experience and knowledge in classroom computer use, and lack of time to experiment. Most substantial computer use occurred where the teacher chose to facilitate student-centred learning in a constructivist framework. Newhouse concluded that "there is little value in investing in computer hardware and software without encouraging teachers to reflect on their beliefs about learning and consider the role of computers in their teaching" (Newhouse, 1999, p. 163).

2.1.1.4 Pre-service and beginning teachers' computer use

A study of 107 pre-service teachers on their final teaching practice was conducted at the University of Southern Queensland (Albion, 1996b). Students generally rated themselves as having little knowledge of computers but 68% reported positive feelings about computers and 63% thought it very important for teachers to know about computers. Most admitted to some nervousness about using computers in the classroom and no more than 50% used a computer during their four weeks of teaching practice. The strongest influences on student teachers' use of a computer for teaching during teaching practice were whether the supervising teacher had been observed using a computer followed by whether there was a computer available in the classroom. The most common problems experienced in the use of computers were organising the class (41%) and lack of personal skill (36%). The study concluded that student teachers need to be exposed to models of appropriate computer use and that courses should give more attention to strategies for teaching and classroom management with computers.

Handler's (1993) study of pre-service computer experiences and current computer uses of 133 recent graduated teachers in the USA found that only 18.8% of respondents indicated feeling prepared by their pre-service program to use computers for instruction. Further analysis of the data identified three factors that contributed to feelings of preparedness, namely, specific coursework in educational computing, the degree to which computers were integrated into methods classes and the observation of and use of computers during field experience.

Another study (Topp, 1996) of 135 recent teacher graduates in the USA found that they rated their pre-service preparation for using computer-related technologies as inadequate. Recurring themes in their responses to open-ended questions about reasons for their rating were the importance of technology in the future of education, the need for a required computer course and that modelling of computer use in university classes was important but generally lacking.

More recently, Strudler et al. (1999) conducted a two year study in which they surveyed a total of over 400 first year elementary teachers in Nevada about a range of issues. Obtaining adequate access to computer resources rated eighth among the top ten problems reported in 1994 and fourth in 1995. In both years, teaching with computers was the area for which they reported they felt least well prepared by both university courses and teaching practice. In the 1995 survey 60% of respondents reported that technology was important or very important for instruction in their content area or grade level. Access to technical support for technology in their schools varied widely, with 40% rating it as none or poor and 39% rating it as good or excellent. The authors concluded that a systematic effort was required to improve preparation and support for teaching with computers.

Prior to receiving formal instruction about integrating computers into teaching and learning, pre-service teachers in Iowa were found to have naïve conceptions about classroom computer use (Sadera & Hargrave, 1999). The scale for assessing students' conceptions of computer use rated informing and reinforcing as simplistic uses when compared to more advanced uses such as experiencing, integrating and utilising. Students with higher computer proficiency scores conceptualised advanced forms of computer use significantly more than students with lower proficiency. Levels of comfort with computers appeared not to affect conceptions of use but students who were less confused about computers or who believed the computer belonged in the classroom conceptualised more advanced uses. The study was intended to establish baseline data and did not report on any effects of subsequent instruction about computer use in teaching.

A recent Australian study of 40 students on teaching practice (Jones, 1998) investigated their levels of computer anxiety, their concerns about using computers in class, and some aspects of accessibility and use of computers in the classrooms where they undertook their field experience. Overall they reported being comfortable and not anxious about computers but 95% reported intense or high concerns about computer use in classrooms. Almost two-thirds believed they had to know more about computers than their students and 52% believed that teachers needed to know a lot about computers before using them in the classroom. As many as 42% of the supervising classroom teachers either did not use the computers at all or used them once in the four weeks of teaching practice despite their having been requested to model computer use and encourage student teachers to use the computers. Reported use of computers by the pre-service teachers during the experience was limited with just 18% using the computer daily and 42% using it just once in the four weeks.

Similarly, a recent study in the UK found that mentor teachers' use of computers had a significant impact on the uptake of computers by student teachers who observed them (Trushell, Slater, Sneddon, & Mitchell, 1998). Students who observed no computer use during their placement made limited or no use of computers themselves. Students who used computers during their placement tended to perceive the in-schools experience as beneficial to their development in using computers in contrast to those who had not used computers.

In seeking to explain what appeared to be consistently low levels of use by pre-service teachers especially on teaching practice, Wild (1996) argued that student teachers needed to identify a purpose for computer use early in their experience with computers in education. He considered the focus of pre-service programs on teaching mainly computer skills to be discredited and suggested that student teachers' construction of meanings for computer use was more likely to be influenced by general rather than specific courses in computing and their personal beliefs about teaching and learning.

2.1.2 Predicting teachers' computer use

The research reviewed to this point has provided some descriptive information about computer-using teachers. It has also provided some indication of the environmental influences that have encouraged their adoption of computers for teaching. However, it is possible that there are additional factors in the personalities of teachers which affect their decisions about using computers and which might be predictive of teachers' computer use.

2.1.2.1 The work of Marcinkiewicz

The most sustained effort to develop some understanding of teachers' personal characteristics that may support predictions about their use of computers appears to have been undertaken by Marcinkiewicz in the USA. His research was a response to the apparent paradox of increasing availability of computers in schools not being matched by a parallel increase in their use by teachers and students.

The first stage of a proposed longitudinal study examined the relationship of "personological variables" to student teachers' expectations of how they would use computers in their teaching (Marcinkiewicz & Grabowski, 1992). The variables that were hypothesised to predict computer use included age, gender, experience with computers, innovativeness, teacher locus of control, perceived self-competence in computer use and perceived relevance of computers to teaching. Innovativeness and locus of control measures were obtained using previously published scales. All other predictor variables were measured by single items on the questionnaire completed by the participants. Of the predictor variables, the first three are not subject to change by intervention but the remaining four might conceivably be modified by various interventions. The selection of this set of predictor variables was based on consideration of relevant theories and prior research which related them to computer use.

For the purposes of the study, computer use was defined as the "integrated employment of computers in the classroom" and it was measured according to a Levels of Use instrument based on a theory of instructional transformation (Marcinkiewicz & Welliver, 1993). The complete model comprises five levels of use, namely, familiarisation, utilisation, integration, reorientation and evolution. At least at a superficial level these five levels resemble the five stages identified in the ACOT studies (Dwyer et al., 1990), namely, entry, adoption, adaptation, appropriation and invention.

The sample for this study comprised 167 undergraduate students in the penultimate year of their teacher education course. Because for undergraduates it was not possible to measure actual levels of computer use in teaching, they were asked to respond to that portion of the instrument in terms of what they expected to be true of their future use of computers in teaching. Of 150 useable responses for that measure, 2.7% were in the non-use group, 84% in utilisation and 13.3% in integration. Possible relationships among the variables were sought using correlation analysis. The only significant correlations with expected use of computers were found for perceived relevance of computers to teaching and self-competence in computer use. Logically, students expected to use computers more in their future teaching if they saw computers as relevant to teaching and felt competent in their use.

A follow-up study was conducted three years later after the graduates had one year of professional teaching experience (Marcinkiewicz & Wittman, 1995). Of the 167 participants from the first phase, 100 participated in the second phase. Actual levels of computing use reported were 39% non-use, 60% utilisation and 1% integration. These levels were lower than expectations but generally better than that of an unrelated group of 170 elementary teachers who reported 43% non-use, 49% utilisation and 8% integration. Unlike in the first phase study, self-competence and perceived relevance did not predict computer use. However, locus of control from the first phase predicted computer use in the second phase. Higher scores on the locus of control measure indicate a stronger sense of personal capacity to affect outcomes in the classroom. Graduates who possess this quality may be less likely to give up when faced with challenges in achieving their expectations, in this case for computer use.

In another study, 138 elementary school teachers were selected from 12 schools where computers had been available (at least one computer per twelve students) for at least three years (Marcinkiewicz & Regstad, 1996). Levels of computer use, measured as in the previous study, placed 31% in the non-use group, 66% in utilisation and 3% in integration. These values were somewhat lower than those reported for expected use by undergraduates (Marcinkiewicz & Grabowski, 1992). The same internal variables were used as in the previous study except that locus of control was substituted by subjective norms which was a measure of "a person's choice to behave based on the influence of others". The only variable found to be a significant predictor of computer use was subjective norms. Marcinkiewicz concluded that "expectations of computer use from among teachers' significant others – principals, colleagues, students, and the profession – are influential in developing teachers' own expectations of computer use". This result is consistent with other studies where the environment in which teachers work was found to influence their decisions to use computers (Becker & Ravitz, 1999; Dexter, Anderson, & Becker, 1999).

More detailed results from the 170 elementary teachers used as a comparison for the longitudinal study (Marcinkiewicz & Wittman, 1995) were reported elsewhere (Marcinkiewicz, 1994a). The sample was selected to ensure that availability of computers was not a contributing factor to differences in levels of use. Under these conditions, self-competence for computer use and innovativeness were the only variables that predicted computer use for teaching. Marcinkiewicz argued that the results obtained for levels of computer use supported its incremental development as described by instructional transformation. This is consistent with the results of the ACOT studies.

In a subsequent paper (Marcinkiewicz, 1994c), direct comparisons were made between the data from the 170 practising teachers and the original group of 167 undergraduate students. Overall, both sets of data reflected perceptions of high relevance of computers in education, strong self-competence for their use and a tendency towards innovativeness. The most significant predictors of computer use (expected use in the case of the undergraduates) were perceived relevance for the undergraduates and self-competence and innovativeness for the practising teachers. The proportion of teachers reporting non-use of computers was much higher than for the undergraduates but, as noted above, when actual use was measured a year after graduation the levels were much closer. Perhaps the most useful outcome of this research is the confirmation that motivational factors may be significant predictors of teachers' computer use.

2.1.2.2 Other predictive studies of teachers' computer use

If, as is suggested by the work of Marcinkiewicz, teachers' perceived level of computer competence is a significant influence on their use of computers, then factors which, in turn, affect perceptions of confidence should be worth investigating. A survey of 234 graduate students in special education courses sought to examine the impact of computer coursework, ownership, access to software and access to computers in the workplace on special education teachers' perceived computer competency (Tyler-Wood, Putney, & Cass, 1997). Regression analysis found that the most significant predictors of computer competence were access to the computer and computer ownership. The implication is that programs that provide training to teachers without ensuring continuing access to the computer may be reduced in effectiveness.

Although not directly pertinent to the use of computers in the classroom, the study by Chiero (1997) of factors affecting US teachers' use of computers for non-instructional activities did reinforce some of the findings from other studies of factors affecting computer use. Non-instructional uses may be important in increasing teachers' comfort with computers and in providing models of use for students. A sample of 36 classroom teachers who were enrolled in three university courses were surveyed about their use of computers for specified tasks, attitudes to computers, obstacles to computer use, available support structures and individual characteristics such as age, gender and teaching experience. A majority of tasks had multiple predictors and modifiable predictors such as support resources were among the most significant, suggesting that appropriate planning may influence teachers' incorporation of computers into their routines. Teachers used computers most frequently for planning tasks and only a minority used them for reflective activities or communication with colleagues. Lack of time was ranked as the most significant obstacle and this may have contributed to the focus on use for essential planning rather than other tasks which may be seen as less urgent. It may be significant that lack of time also ranks high among reported barriers to instructional use of computers (Becker, 1994; Hadley & Sheingold, 1993).

Dawson (1998) reported on a study in which a random sample of 300 teachers from 53 elementary schools in the eastern USA were surveyed about their instructional uses of computers and factors that might influence those uses. Regression analysis was used to test the prediction of instructional computer use from measures of skill, support and self-efficacy. Instructional computer use comprised three factors representing *Traditional Instructional Computer Use* (skills and extension work), *Instructional Computer Use via Curricular Integration* (writing, communication and research skills) and *Instructional Computer Use as Reward for Completing Work* (reward for completed work. Teachers reporting both traditional uses and integration reported having training for integration. The main difference between these groups was their perception of their ability to use computers in instruction which is essentially similar to the results reported by Marcinkiewicz (1994a). Support, both technical and peer, was also an important factor.

2.1.3 Making sense of teachers' computer use

Of the twenty-one empirical studies reviewed in the preceding sections, fifteen were conducted in the USA, four in Australia and one each in the UK and Canada. Where directly comparable studies have been conducted in different countries, as in the Australian replication (Sherwood, 1993) of a US study (Hadley & Sheingold, 1993), the results have supported the conclusion that trends in the educational use of ICTs are similar across developed countries.

Seven of the studies covered all levels of schooling, ten focused on primary or elementary schools and teachers, two on secondary and two on special education. The scope ranged from nationwide surveys involving hundreds of teachers (Becker, 1994; Hadley & Sheingold, 1993; Sherwood, 1993) to a case study of a single classroom (Olson, 1992). The overall scope of the studies is sufficient to suggest that any common patterns that emerged might be representative of what is happening more widely.

Based on the results of the survey studies (Becker, 1994; Hadley & Sheingold, 1993; Sherwood, 1993) it seems that, at least at the time of the surveys, teachers who might be regarded as in some way exemplary in their use of computers displayed some common characteristics. They were predominantly experienced males who had invested some personal effort in becoming familiar with computers and had taken three to five years to develop their successful approaches to integrating computers in their classrooms. Over that time their approaches to teaching had become progressively more student-centred. The schools in which they worked were supportive of their computer use but these exemplary teachers indicated that they would appreciate additional support and resources.

There is consistent evidence that it requires a considerable period of time for teachers to come to terms with the integration of computers. The ACOT studies identified a series of stages through which teachers passed (Dwyer et al., 1990). At least superficially, these appear similar to the five levels of use identified in other studies (Marcinkiewicz & Welliver, 1993). Aspects of the stages are apparent in the results of other research. For example, Miller and Olson's (Miller & Olson, 1994) description of how a teacher used computers as an extension of traditional practice aligns with the *adoption* stage. The widespread use of word processors uncovered by the survey research (Becker, 1994; Hadley & Sheingold, 1993; Sherwood, 1993) may correspond to *adaptation* and the relatively small proportion of teachers who qualified as exemplary computer-users and who modified curriculum in favour of group projects (Becker, 1994) may correspond to the *appropriation* stage. The relative rarity of exemplary computer-using teachers (Becker, 1994) and length of time using computers (Hadley & Sheingold, 1993) may tend to confirm the need to progress through a developmental process such as that identified in the ACOT research (Dwyer et al., 1990). If they have taken longer to work through the stages than the ACOT teachers, that may be a reflection of differences in levels of access to computers and support.

Overall it seems that computer-using teachers are likely to have worked through a significant process of development in their use of technology which may have taken several years and which may not yet be complete. The further they have progressed through the process, the more likely they are to have de-emphasised teacher-centred activity in their classrooms in favour of more student-centred approaches. They are less likely to favour instruction where they impart facts and skills to students and more likely to adopt constructivist approaches in which students build their own knowledge, often through collaborative projects in which technology plays a prominent role. The association between student-centred, constructivist approaches to classroom practice and the use of computers is a consistent finding across the research on computer-using teachers. It was reported by survey research (Becker, 1994; Hadley & Sheingold, 1993; Sherwood, 1993), in the ACOT studies (Sandholtz et al., 1994) and in several other studies (Honey & Moeller, 1990; Newhouse, 1998, 1999; Swan & Mitrani, 1993).

Other significant factors influencing teachers' use of computers for teaching were their sense of competence in computer use (Marcinkiewicz & Grabowski, 1992; Marcinkiewicz & Welliver, 1993), the influence of the work environment, including example and support from peers and supervisors (Albion, 1996b; Becker, 1994; Hadley & Sheingold, 1993; Marcinkiewicz, 1994b; Marcinkiewicz & Regstad, 1996; Sherwood, 1993; Trushell et al., 1998), and attitudinal factors including their belief in the usefulness of computers and in their personal capacity to use them in class (Albion, 1996b; Dawson, 1998; Marcinkiewicz, 1994c; Marcinkiewicz & Grabowski, 1992; Marcinkiewicz & Welliver, 1993; Sadera & Hargrave, 1999).

Several studies reported that the ways in which teachers used computers in their teaching were consistent with their existing beliefs relevant to teaching (Honey & Moeller, 1990; MacArthur & Malouf, 1991; Miller & Olson, 1994; Wild, 1996). However, other studies suggested that changes in approaches to teaching resulted from the use of computers (Hadley & Sheingold, 1993; Sandholtz et al., 1994; Sherwood, 1993). The evidence leaves little room for doubt that exemplary teaching with computers is more likely to be associated with constructivist teaching practices than with more traditional instruction. However, there has been debate about whether the association indicates a change in teaching approaches by teachers who use computers or whether it simply indicates that teachers who favour constructivist approaches are more likely to use computers for teaching. Recent research has sought to clarify this issue.

2.1.4 Does the use of ICTs change teachers?

Dexter et al. (1999) reported on data obtained from interviews conducted with 47 teachers at 20 US elementary, middle and high schools as part of a larger preliminary study for a national survey of teachers' instructional beliefs and practices. In the interviews, teachers were asked questions about changes they had made to their teaching and were asked to comment on whether computers had changed their approach or helped them to make changes they already wanted to make. In another element of the study teachers had responded to a questionnaire which covered topics including the value of socially mediated learning and strategies for making learning meaningful to students. Based on data obtained from the questionnaire and validated using other data, the teachers were designated as "nonconstructivist" (15 teachers), "weak constructivist" (22) or "substantially constructivist" (10). The first group tended to view learning as mastery of skills and recall of facts. The second group had practices somewhat distinct from traditional teaching in that they incorporated greater focus on understanding rather than mere recall and used interpersonal processes for learning but with direction coming mostly from the teacher. The third group had sharply different practices, frequently incorporating creative instructional activities, individual or group projects and links to student interests.

Teachers in each of the groups reported having made changes in their instructional practices over the previous few years. In each group it was clear that the computer did not automatically cause more constructivist practices but that there were several reasons for change, including experience and reflection on it, formal learning experiences and school culture. Among those towards the constructivist end of the continuum, the only catalysts to change appeared to be reflection upon experience and schoolwide initiatives. Reflection on experience was cited as a catalyst for change by teachers at both ends of the constructivist continuum and the direction of change was apparently determined by other factors such as school culture.

This study (Dexter et al., 1999) appears to have provided no support for the view that computers are a catalyst for instructional change. The authors concluded that the view of computer as catalyst underestimates the impact of teachers' beliefs on how they teach, simplifies the processes of professional growth and diverts attention from examination of how social norms and structures influence change. The evidence suggests that, if teachers decide to use the computer in a constructivist manner, they do so, not because of features inherent in the technology but, on the basis of their knowledge and expertise.

> For that knowledge to include the use of computers, teachers must have opportunities with computers, models of how computers work in instruction, and opportunities to reflect on their and the computer's roles in the learning process. In other words, they must be allowed to construct knowledge about educational technology. (Dexter et al., 1999, p. 237)

Becker and Ravitz (1999) considered the question of whether, in schools with appropriate support networks and technological infrastructure, computer use might lead to more constructivist teaching practices. They analysed survey data obtained from 441 teachers in 151 US elementary and secondary schools that participated in a project involving substantial Internet use. The schools and other parties in the project had strong education reform agendas that included support for constructivist educational approaches. The sample of teachers was drawn to represent two groups comprising the most active Internet users and the remaining teachers in the schools. All teachers responded to a series of questions about their teaching responsibilities, uses of software, perceptions of the Internet and its relevance to their teaching, the extent to which they believed that change had occurred in each of 19 aspects of their teaching practice over the past several years, whether they believed that computers had contributed to that change and whether they had found the Internet to have affected their teaching in that way. Answers were sought to questions about the association between use of computers and changes towards more constructivist teaching approaches and the role that technologies might have in facilitating the changed practices.

The data supported the conclusion that teachers who had students making substantial use of computer software for several years or who were among the most active Internet users for classes were the same teachers who were most likely to report that their teaching had changed in a constructivist direction over the previous three years. Significant numbers in both of these groups of teachers indicated that computers influenced the changes they had reported in their teaching. Use of computers and the Internet appeared to be particularly related to teachers' learning from or with students, orchestrating multiple simultaneous activities in class, assigning long and complex projects and giving students greater choice in tasks and resources. Each of these changes can be seen as a way of empowering students to take charge of their own learning.

At first glance, there appears to be an implied contradiction between the conclusions of these two studies. The first (Dexter et al., 1999) found no evidence to support the proposition that computers influence teachers' decisions to adopt more constructivist practices. However, the second (Becker & Ravitz, 1999) reported that computers had influenced changes in teaching practice. Despite the presence of a common author (Becker) in both studies, there is no attempt to reconcile the results and neither paper refers to the other.

One possible explanation lies in the differences in the questions that were asked. In the first study, the question included the suggestion that the computer might have helped the teachers to make changes they already wanted to make. In the second, the question referred to the computer as a "primary or contributory factor" to the changes. It would be quite consistent for a teacher to believe that the changes were self initiated but that the computer was a contributory factor which enabled the change. Unfortunately the second study does not distinguish between teachers who considered the computer to be a primary factor and those who saw it as merely contributory.

An alternative resolution may lie in the differences between the schools which make up the samples for the two studies. In the first study, both traditional and reform-oriented schools were selected and the conclusions pointed to the importance of school culture as a contributing factor in teachers' decisions to change their practices. In the second study, the schools were self-selected for reform orientation by virtue of their involvement in the project. It may be that teachers perceived the influence of computers on their decisions to be relatively greater when they were immersed in an environment that encouraged the types of changes they were making.

2.1.5 Educating computer-using teachers: Summary of directions from the research

It is clear from the research that there are numerous factors which may influence the use of computers by experienced or beginning teachers. Some factors such as access to computer resources, local support and school culture are beyond the direct reach of teacher preparation programs although changes in those areas might usefully be initiated by school authorities. However, there are some factors that are amenable to change through teacher preparation. Identifying these factors, and selecting those that are most capable of influencing teachers' use of computers and which can themselves be affected by teacher development activities should be a priority for teacher educators.

Twining (1995) suggested that course design should be informed by a model of how pre-service teachers develop competence with IT and that competence would be linked to students' mental models of computers. His research found that there was no relationship between the level of technical sophistication in students' mental models of computers and their computer competence. However, competence was linked to the level of abstraction of the mental models. He suggested that variations among computer systems and software and rapid changes in technology meant that a more abstract model made for easier adaptation to changing technology and that teacher education programs should seek to assist students in developing appropriate mental models.

Oliver (1993) reported on a study which investigated the effects of different forms of computer education in a pre-service course on the computer uptake of 122 primary and secondary beginning teachers in Western Australia. Beginning teachers judged themselves to make substantially less use of computers in their teaching than other teachers in the same schools. Moreover, among the secondary teachers, for whom the university computer course was optional, the level of uptake appeared to be similar regardless of whether they had taken the course or not. The computing course for secondary teachers had focused on personal computer skills and Oliver concluded that his findings did not support the argument that developing strong computer skills is sufficient to ensure that the computers will be used for teaching. The computing course for primary teachers focused on curriculum applications. Comparisons between primary and secondary graduates who had taken the computing courses with different emphases revealed that secondary graduates made significantly more total use of computers than primary graduates. This was related to their higher levels of use for administrative and personal purposes whereas primary graduates used the computer significantly more in their classroom teaching. These findings support the desirability of computing courses for teacher education students having a strong focus on curriculum applications.

According to Oliver (1994), "confidence and competence in personal computer use, the aim of many IT courses in teacher education, may be a *necessary* condition for classroom computer use but alone is not *sufficient*" (p. 140). Oliver argued that what was needed was instruction that focused on relevant approaches to implementing technology in the classroom and that this could best be accomplished by integrating computer technologies into teacher education courses rather than including discrete subjects dealing with IT.

Sherwood (1993) noted that, in the past, "IT training has been minimal and computer based rather than curriculum linked" (p. 178). Basic skills and confidence in the use of computers are important attributes of computer-using teachers but Sherwood suggested that teachers are now wanting in-service courses to be directed more at the classroom than at basic skills. She added that many are wishing to "visit classrooms to view exemplary practice in action" (p. 178). That desire is implicit in several of the studies that identified the need for both practising and student teachers to have access to suitable models of practice in computer use. Access to suitable models would assist teachers in building a repertoire of behaviours for effective use of computers in their teaching.

A study of ACOT Teacher Development Centre activities found that the "overriding strength of the practicum to participants is that it is situated in real ACOT classrooms during the school year" (Ringstaff, Yocam, & Marsh, 1996, p. 10). Being in a real school allowed participants to see computers in use in a context similar to their own classrooms which made it easier to transfer what they learned. Most teachers returning from the practicum began to change their practices towards a more constructivist approach. Novice computer users began to use computers more frequently and more experienced users moved from drill and practice towards use of tool software. Teachers who had technical support in their own school were more likely to persist with the changes.

A recent survey of information technology in teacher education in the USA obtained data from 416 institutions (Moursund & Bielefeldt, 1999). It found that technology infrastructure in teacher education was generally perceived to be adequate but that teacher educators' IT skills tend to be comparable to those of their students. Moreover, most teacher educators do not model the use of IT in their teaching. The majority (85%) of institutions had specific IT course requirements but the survey data suggests that these courses are not strongly related to other aspects of IT use, with even applications skills of the students having little correlation with formal IT coursework. There was evidence that IT instruction included in other subjects was more effective than specific IT courses in helping new teachers integrate computers in schools. The authors concluded that access to models of appropriate technology use was an important part of teacher education. They suggested that attention be given to modelling of computer use in teacher education, making available exemplars of effective technology use and providing students with more opportunities to work with computers during field experiences.

Another recent report from the USA dealt with professional development for teachers in the use of information technology (CEO Forum, 1999). Its recommendations for professional development included modelling best practice with technology within the development program and encouraging learning by doing.

It is not surprising that encouraging teachers to use computers in their teaching is so strongly linked to the existence of appropriate role models. The research on computer-using teachers suggests that success with computers in the classroom involves teachers in adopting new behaviours. For most teachers an opportunity to see those behaviours demonstrated will be an important factor in their being able to make the necessary changes.

Even allowing that teachers have access to appropriate role models, adapting classroom behaviours to integrate ICTs may present a significant challenge. During initial teaching experience, the demands of curriculum and classroom management leave little time or energy for adoption of technology (Moursund & Bielefeldt, 1999; Oliver, 1993). Teachers would need to be convinced that the potential benefits of incorporating ICTs would be sufficient to justify the effort.

As noted previously, studies conducted with pre-service teachers have found that attitudes towards the use of computers in teaching are generally positive. Despite rating themselves as having little knowledge of computers, 63% of 107 student teachers in an Australian study thought it very important for teachers to know about computers (Albion, 1996b). Other studies have reported similar results. Among 200 US students, 60% reported that technology was important or very important for instruction (Strudler et al., 1999). Responses from a group of 135 US student teachers to open-ended questions frequently mentioned the importance of technology to the future of education (Topp, 1996). Both pre-service and practising teachers perceived computers as having high relevance in education (Marcinkiewicz, 1994c).

On the basis of this research it appears that a majority of teachers, both newly graduating and experienced, may be disposed to believe that ICTs are important to education. Despite this belief and a working environment which offers support through policy and increasingly ready access to ICTs for use in teaching, the application of computers for teaching and learning is still described as "patchy" (Galligan et al., 1999, p. 1). Clearly an alternative explanation must exist.

Several researchers have reported that teachers or student teachers appear to lack confidence in their ability to use computers successfully in the classroom. Dawson (1998) observed that perception of their ability to use computers in instruction was the main difference between teachers practising curriculum integration with computers and those reporting mostly traditional uses of computers. She argued that training should be designed with the goal of developing teachers' confidence in their ability to use computers in the classroom.

If, as Oliver (1994) suggested, technical competence with computers is not sufficient to ensure teachers' success with them in the classroom, it may be that the missing ingredient is belief in the capacity to use that competence. In other words, teacher educators need to attend to the development of teachers' beliefs in their capacity to do what is required to succeed with computers.

2.2 Teachers' beliefs about teaching with ICTs

If the key to encouraging more teachers to integrate ICTs into their teaching is to change their beliefs in their capacity to work with ICTs, then it becomes necessary to investigate the nature of teachers' beliefs, what specific aspects of belief might influence their confidence for teaching with ICTs and how those beliefs might be changed to increase teachers' confidence for classroom use of ICTs.

This section will address those issues, beginning with a brief review of research on the nature of teachers' beliefs and their effects on teachers' behaviour. That will be followed by consideration of research on self-efficacy beliefs as central influences on behaviour. Research related to changing beliefs and specifically self efficacy will be reviewed, before conclusions are drawn about the type of professional education which might be successful in changing self-efficacy beliefs about teaching with computers.

The literature search in this section began with thorough searches of the ERIC database for material related to self-efficacy beliefs of teachers, especially in relation to computer use. Reading in this literature highlighted its connection to the broader area of teacher beliefs (Pajares, 1992) and significant citations were consulted to provide a broader context within which to consider self-efficacy beliefs.

2.2.1 The nature of teachers' beliefs

Human behaviour is subject to influence from a variety of sources. Richardson (1996) identified attitudes and beliefs as a subset of a group of such constructs which also includes "conceptions, perspectives, perceptions, orientations, theories and stances" (p. 102). She noted that a belief is accepted as true by the individual holding the belief and differs from knowledge which requires support from evidence. The relationship between belief and action is complementary, beliefs influencing actions and, in turn, being modified by experience. In the context of teacher education, beliefs are important as influences that students bring with them and as a focus of instruction which helps students to form belief systems that are more solidly based on evidence and reason (Richardson, 1996).

The importance of teacher thinking and of teachers' beliefs as an area which had received scant attention to that time was recognised by Munby (1982), who noted that beliefs "bias our interpretation and recall of evidence, leading us to recognize more readily confirming evidence than disconfirming evidence" (p. 206). He used a repertory grid technique to guide interviews which uncovered beliefs that influenced the thinking of teachers and suggested that the technique could be extended to examine the interplay between beliefs and decisions taken in the course of planning and instruction.

Nespor (1987, p. 318) delineated six structural features of beliefs that distinguish them from other forms of knowledge. First, belief systems involve "existential presumption". That is, they frequently contain propositions about the existence or non-existence of entities. In teachers' beliefs these may be manifested as strong beliefs about characteristics of students such as "ability" or "maturity" which may be seen as beyond the influence of the teacher. Second, they entail "alternativity", which refers to the inclusion in belief systems of conceptualisations of ideal situations which enable beliefs to serve as a means of defining goals and tasks. Third, belief systems are much more concerned than knowledge with "affective and evaluative aspects" which can affect the amount of effort directed towards an activity based on its perceived value. Fourth, whereas knowledge may be stored in semantic networks, belief systems may rely more on "episodic storage", organised in terms of personal experiences, episodes or events. The power of beliefs may be derived from critical episodes. Fifth, belief systems are non-consensual. That is, they consist of propositions that are recognised as being, at least in principle, disputable. Characteristics such as dependence upon experiential episodes, existential presumption and affect mean that belief systems are not open to outside evaluation in the same way that knowledge systems are. Sixth, belief systems are loosely-bounded. Although beliefs may have stable core applications, that is, a domain in which they are consistently held to be applicable, they can be "extended in radical and unpredictable ways to apply to very different types of phenomena" (p. 321). Knowledge systems can be extended to new phenomena only through logical argument.

Pajares (1992) reviewed and extended many of these ideas from Nespor (1987). He observed that other researchers had noted the episodic nature of beliefs as described by Nespor:

> Goodman (1988) discovered that teachers were influenced by *guiding images* from past events that created *intuitive screens* through which new information was filtered. Calderhead and Robson (1991) reported that pre-service teachers held vivid images of teaching from their experiences as students … that … played a powerful role in determining the practices they would later undertake as teachers. Eraut (1985) wrote that unsystematic personal experience, taking the form of photographic images residing in long term memory, played a key role in the process of creating and recreating knowledge. (Pajares, 1992, p. 310)

The episodic nature of beliefs is important to understanding how they are formed or changed and how they come to influence behaviour in ways that the patterns of rational thought associated with knowledge may not.

There is evidence (Pajares, 1992) to support the claim that beliefs are held in clusters and that some are more central and resistant to change. The separation of clusters of beliefs may be such that it is possible for a person to simultaneously hold conflicting beliefs. "Clusters of beliefs around a particular object or situation form attitudes that become action agendas" (p. 319). Only when circumstances bring both clusters of belief into play does the dissonance become apparent and require resolution.

2.2.2 Beliefs and teacher behaviour

Nespor (1987) argued that two key areas where beliefs impacted on teacher behaviour were in task definition and knowledge organisation. As an example of the impact on task definition, Nespor described the case of two teachers, one of whom viewed teaching as merely a job and the other as a moral mission to socialise children and improve the world. Failure to recognise the different meanings arising from their belief systems would render it impossible to make sense of their classroom actions because they were performing fundamentally different tasks. In relation to memory, Nespor cited work by Spiro on the experiential qualities associated with the storage of memories of events. The suggestion is that elements in memory may be related by emotional or attitudinal colouring which may assist in recall but also leads to filtering of content that does not accord with the overall emotional colouration of the particular association.

According to Nespor, the contexts and environments of teachers' work make beliefs especially potent for defining tasks and organising the relevant knowledge. Teaching frequently involves dealing with ill-structured problems characterised by a large amount of information, open constraints and the absence of a single correct solution (Voss & Post, 1988). Indeed, "research on teacher belief suggests that the most significant characteristic of classroom teaching is its many uncertainities" (Kagan, 1992, p. 79). Nespor suggested that beliefs are particularly suited to making sense of such contexts because, under such conditions, "many standard cognitive processing strategies … are no longer viable" (p. 325). Rather, what are required in such circumstances are knowledge structures that can be accessed and examined from different perspectives. Nespor argued that the episodic nature of belief systems made them good candidates for this purpose and that the unbounded quality of beliefs made it possible to map the recalled cases onto new events or experiences. Additionally, the nonconsensual nature of beliefs would render their application relatively immune to contradiction. Thus beliefs are capable of flexible application to novel problems. In his review of this aspect of Nespor's work, Pajares (1992, p. 312) cited work by Calderhead and Robson (1991) who noted that "pre-service teachers use episodic images as recipes for action but do not have the knowledge to question or modify them before or during the task at hand".

According to Kagan (1992), research on teachers' beliefs pointed consistently to two generalisations. Teachers' beliefs are relatively stable and resistant to change and tend to be associated with a congruent style of teaching. She argued that teachers' judgments about their work depend upon the particular students with whom they are working, the content to be taught and their own prior experience and related beliefs.

Pajares (1992) cited several sources in support of the assumption that "beliefs are the best indicators of the decisions individuals make throughout their lives" (p. 307). He summarised research on teachers' beliefs as suggesting a "strong relationship between teachers' educational beliefs and their planning, instructional decisions, and classroom practices" (p. 326) and that "educational beliefs of pre-service teachers play a pivotal role in their acquisition and interpretation of knowledge and subsequent teaching behaviour" (p. 328). In his view, beliefs were 'far more influential than knowledge in determining how individuals organise and define tasks and problems and are stronger predictors of behaviour" (p. 311).

2.2.3 The construct of self-efficacy beliefs

The construct of educational beliefs is "broad and encompassing" and has been refined into more specific sub-constructs (Pajares, 1992, p. 316). Examples cited by Pajares include beliefs about confidence to affect students' performance (teacher efficacy), about the nature of knowledge (epistemological beliefs), about perceptions of self (self-concept) and about confidence to perform specific tasks (self-efficacy). The latter is of particular interest because of the role it is proposed to play in determining behaviour.

The theory of self-efficacy has been developed by Bandura (1977; 1986; 1997). In essence, it represents the recognition that in order to function competently one must have both the necessary skills and the confidence to use them effectively. Stated more formally, "perceived self-efficacy refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). Self-efficacy is concerned, not with the level of skill possessed by a person, but with judgements about what can be done with whatever level of skill exists. It is common experience that people sometimes do not behave optimally despite knowing what to do. The reason is that self-referent thought (self-efficacy) mediates the relationship between knowledge and action and perceived self-efficacy is a significant determinant of performance that operates partially independently of underlying skills (Bandura, 1986).

Self-efficacy is one of a cluster of constructs which deal with ideas of the self. Because its focus is on judgements of self-capability, it stands apart from other constructs such as self-esteem, which is concerned with judgements about self-worth, and self-concept, which is a collection of beliefs about the self (Olivier & Shapiro, 1993). Bandura (1977) identified two components of self-efficacy. Efficacy expectations are related to the belief that a person can accomplish the behaviour required to produce a particular outcome. Outcome expectations are an estimation that a specific behaviour will produce a certain outcome. "Efficacy and outcome judgements are different because individuals can believe that a particular course of action will produce certain outcomes, but they do not act on that outcome belief because they question whether they can actually execute the necessary activities" (Bandura, 1986, p. 392). As a consequence, instruments for the measurement of self-efficacy typically include two scales to measure both efficacy expectations and outcome expectations.

Bandura (1997) argued that "beliefs of personal efficacy constitute the key factor of human agency" (p. 3). Research in a variety of contexts, including general health behaviours, treatment of phobias, self-regulation of pain, academic performance and career development, has provided supporting evidence (Bandura, 1986).

2.2.3.1 Self-efficacy beliefs for teaching

The earliest application of Bandura's theory of self-efficacy to the study of teacher efficacy appears to have been by Ashton and Webb in 1982 (as cited by Guskey, 1998). They aligned outcome expectations with perceptions of the consequences of teaching in general and labelled the dimension as "teaching efficacy". They aligned efficacy expectations with teachers' perceptions of their personal ability to achieve desired results and labelled that dimension as "personal efficacy".

Subsequently Gibson and Dembo (1984) developed a 30-item instrument and, through factor analysis, confirmed a two factor model which they interpreted as matching the factors identified by Ashton and Webb. Woolfolk and Hoy (1990) refined the Gibson and Dembo instrument by removing and adding items before confirming the two factor model and applying the same interpretation as Gibson and Dembo. However, they raised some questions about the interpretation of the two dimensions, in the light of the observation that items loading on the teaching efficacy factor were all worded negatively while those loading on the personal efficacy factor were all worded positively.

Guskey and Passaro (1994) re-examined the construct of teacher efficacy using an instrument based largely on the modified version produced by Woolfolk and Hoy (1990). They reworded the items so that each dimension had a balanced mix of positively and negatively worded items and items with internal and external orientations. Under these conditions the interpretation of the two factors as teaching efficacy and personal efficacy did not hold. Instead they found an internal-external distinction. The internal dimension relates to belief that teachers, personally and generally, have a capacity to influence students' learning. The external dimension relates to beliefs about the influence of factors outside the classroom and beyond the immediate control of the teacher. This internal-external distinction is not the same as in locus of control measures in which the factors would represent opposite poles of a bipolar scale (Guskey, 1998). The two factors are relatively independent. For example, some teachers could believe that, despite difficult social conditions, they can have a powerful influence on students. At the same time, others could believe that their ability to affect students is limited regardless of external conditions.

Soodak and Podell (1996) reported the results of a further variation on the Teacher Efficacy Scale (Gibson & Dembo, 1984). They obtained a three factor solution which they compared to the factor loadings on equivalent items as published by previous researchers (Gibson & Dembo, 1984; Woolfolk & Hoy, 1990) and found to be generally similar. They suggested that the three factor solution could be interpreted in terms of personal efficacy concerning teachers' beliefs about their ability to perform specific behaviours, outcome efficacy relating to teachers' beliefs that student outcomes were attributable to their actions, and teaching efficacy which concerned beliefs about the influence of external factors on the impact of teaching. They argued that this interpretation was a better fit to the theoretical model of self-efficacy (Bandura, 1977) in terms of the basic elements of efficacy expectations and outcome expectations.

Despite the difficulties in interpreting the teacher efficacy scales, researchers have found that measures obtained using the scales were related to a variety of other variables. Dembo (1985) claimed a potential relationship to different school organisational patterns and to classroom behaviour known to yield achievement gains. A positive relationship of teacher efficacy to a humanistic pupil control orientation has been found for both prospective teachers (Woolfolk & Hoy, 1990) and practising teachers (Woolfolk, Rosoff, & Hoy, 1990). Other researchers have reported that teacher efficacy, measured using various instruments derived from the Gibson and Dembo scale, "showed small but significant positive correlations with ratings of lesson presenting, classroom management, and questioning behaviours" (Saklofske, Michayluk, & Randhawa, 1988, p. 414); was positively related to change in individual teacher practice (Smylie, 1988); was positively related to success in implementing programs of innovation (Guskey, 1988; Stein & Wang, 1988); and was positively correlated with teachers' attitudes toward implementing new instructional practices (Ghaith & Shaaban, 1999). A study of factors which might affect teaching performance of pre-service teachers at the end of their course found that perceived self-efficacy was a strong predictor (Jablonski, 1995).

Although using different measures for self-efficacy, a recent study found that self-efficacy can play an important role in change processes (McKinney, Sexton, & Meyerson, 1999). Participants with lower efficacy beliefs expressed concerns typical of those in an early stage of change (self concerns) while those with higher efficacy had concerns characteristic of later stages of change (impact concerns).

Pajares (1996) noted that "judgements of self-efficacy are task and domain specific" (p. 547). The measures of teacher efficacy discussed above are specific to teaching as compared with alternative occupations or activities but teaching itself comprises a variety of more specific sub-domains. Riggs and Enochs (1990) described the development of a Science Teaching Efficacy Beliefs Instrument (STEBI) constructed on the model of the Gibson and Dembo instrument. Analysis confirmed the two factor structure of the instrument and the reliability of the scales. Validity was checked by comparing results obtained from the STEBI with other data obtained from a sample of 300 elementary teachers. Consistent with previous reports (Woolfolk & Hoy, 1990; Woolfolk et al., 1990), personal science teaching self-efficacy of pre-service science teachers, as measured by the STEBI, was positively correlated with humanistic orientations to classroom management, and with prior study of science, respondents' choice of instructional delivery and perceived effectiveness in teaching science (Enochs, Scharmann, & Riggs, 1995).

Measures of teacher efficacy or self-efficacy for teaching are still problematic in terms of their interpretation. Nevertheless, the construct has been used in a variety of studies and has been found to be consistently useful as a tool for understanding teachers' behaviour. Further study, including investigation of its relationship to teachers' use of computers, would be justified.

2.2.3.2 Self-efficacy beliefs for computer use

Olivier and Shapiro (1993) reviewed the research on self-efficacy and computers. Overall the research on self-efficacy in respect of several different fields of behaviour indicated that persons with higher self-efficacy tend to be higher achievers than those with lower self-efficacy. They cited early studies by Lewis who found that direct experience with computers positively influences development of self-efficacy and Robbins who found that males typically had higher levels of computer self-efficacy than females. The nature of the technology at that time resulted in most of these early studies of computer self-efficacy having an emphasis on the use of terminal systems, computer programming and the mathematical and technical aspects of computing. As a consequence, they are of limited relevance to present day computer users. Olivier's own dissertation work on "the relationship of selected teacher variables with self-efficacy for using the computer for programming and instruction" is cited. Its principal findings are reported as showing significant, positive relationships between mathematics confidence and programming efficacy and between number of courses taken and mathematics ability and instructional efficacy. Olivier interpreted these results as suggesting that cultivating positive attitudes towards mathematics would increase mathematics confidence and hence computer self-efficacy. History has moved on, and success with computers is now as likely to be dependent upon language or artistic capacity as mathematics. However, the early research on computer self-efficacy did highlight the significance of the construct and laid foundations for more recent work. Its conclusion that "there is evidence to support the importance of the construct as a critical predictor of future trends in computer attitudes and usage patterns" (p. 84) remains true in the broadest sense although the technology and its uses are evolving.

There are some earlier studies of computer self-efficacy which continue to have relevance because their findings contribute to confirmation of aspects of theory or because the instruments they developed are still used. Hill, Smith and Mann (1987) investigated the relationship between computer efficacy beliefs and decisions to use computers using an instrument developed for the purpose. The participants were 300 undergraduate students in an introductory psychology course who completed a questionnaire at the beginning of the study and twelve weeks later were asked about their decision to take a computer course. Data were analysed using structural equation modelling. The study found that perceived efficacy with respect to computers was an important factor in a decision to use them. Although previous experience with computers contributed to computer efficacy it did not directly affect subsequent behaviour regarding adoption of computer technology. The authors concluded that this finding was consistent with Bandura's (1977) theory in that experience increased efficacy but the effect of experience on behaviour was mediated by efficacy beliefs.

The Computer Self-efficacy Scale

The Computer Self-efficacy Scale (CSE) developed by Murphy, Coover and Owen (1989) has been used in its original or modified form in several studies of self-efficacy for general computer use. Although the original paper refers specifically to Bandura's theory of self-efficacy, the scale does not conform to the two factor pattern. Instead there are three sub-scales related to different aspects of computer use. The existence of these three factors was confirmed by analysis. Further validation of the instrument was undertaken in a subsequent study (Harrison & Rainer, 1992) which confirmed the three factor structure of the scale and established its concurrent validity with other instruments measuring computer attitudes and computer anxiety. A further analysis (Torkzadeh & Koufteros, 1994) identified four factors with an overall distribution of items similar to the earlier analyses except that one scale loaded onto two factors. The instrument was used to measure the computer self-efficacy of 224 undergraduates before and after an introductory computer course. Significant increases in self-efficacy scores were recorded on each of the four factors. The four factor structure of the scale and the relationship between experience with computers and self-efficacy for computer use were confirmed by a more recent study (Moroz & Nash, 1997).

Despite its neglect of the structure of the self-efficacy construct (Bandura, 1977), in that it did not address outcome expectancy, and its inclusion of items related to somewhat dated aspects of computer use such as mainframe access and programming, the CSE (Murphy et al., 1989) continues to be used for research. In a study involving a sample of 776 US university employees' self-efficacy as measured by the CSE, the researchers found a significant correlation between self-efficacy and performance with computers in the work environment (Harrison, Rainer, Hochwarter, & Thompson, 1997) thus adding support to the claim that self-efficacy is related to behaviour. Students' attitudes towards computers (comfort/anxiety and usefulness) were found to predict self-efficacy (CSE) which, in turn, was negatively correlated with desire to learn about computer technology (Zhang &

Espinoza, 1998). Prior computer experience was found to contribute to computer self-efficacy which, in turn, was significantly related to performance of students in an introductory computer literacy course (Karsten & Roth, 1998). A version of the CSE in which some items were adjusted to account for local context was used to investigate the self-efficacy of Australian teacher education students (Jones, 1999). This study found that students generally had confidence in their ability to perform a range of basic computing skills but were less confident about more advanced topics which implied more technical knowledge of computers.

The Self-efficacy for Computer Technologies instrument

An alternative to the CSE, the Self-efficacy for Computer Technologies (SCT) instrument, was developed, at least in part, to address perceived deficiencies of the CSE in relation to newer technologies such as electronic mail and CD-ROM databases (Kinzie & Delcourt, 1991). It was subsequently expanded to include six sub-scales covering spreadsheets, database programs, electronic mail, word processing, statistical packages and CD-ROM databases (Kinzie, Delcourt, & Powers, 1994). The expanded form was validated with a mixed sample of 359 undergraduate students of business, education and nursing. Factor analysis confirmed the structure of the scales which were found to be statistically reliable. The researchers also reported that prior experience with computers and attitudes measured in the study both contributed significantly to the prediction of SCT values.

Although the SCT, like the CSE, does not attend to the outcome expectancy component of self-efficacy theory, it has also been adopted by other researchers. A study of students in a "computer applications in physical education" course was conducted using the SCT sub-scales for word processing, electronic mail and CD-ROM databases (Ertmer, Evenbeck, Cenmano, & Lehman, 1994). Students were randomly assigned to conditions in which they were required over eight weeks to communicate with the instructor by word processor, electronic mail or handwritten notes. At the end of that time there was a period of three weeks in which students were free to select their own method of communication. The SCT was administered three times, once at the beginning of the course, at the point where students were permitted to select their medium of communication, and finally at the end of the experiment. Prior experience with computers contributed to students' self-efficacy levels as measured on the pretest. Self-efficacy for word processing and electronic mail increased significantly during the course but the increases were not directly related to time on task and the researchers suggested that quality of experience may be more critical than quantity.

Other measures of self-efficacy for computer use

A survey of Canadian managers and professionals was used to develop and validate a measure of computer self-efficacy (Compeau & Higgins, 1995). The study found that computer self-efficacy had a significant effect on outcome expectations related to computer use and computer anxiety as well as on actual computer use. Both self-efficacy and outcome expectations were positively influenced by encouragement in the workplace and by seeing others use computers. A subsequent study using the same instrument found that self-efficacy was a significant predictor of computer anxiety and of computer use up to a year after measurement of self-efficacy (Compeau, Higgins, & Huff, 1999).

Brosnan (1998) investigated the effects of computer anxiety and self-efficacy on performance of computer related tasks. The measure of self-efficacy was a task self-efficacy scale (Gist, Schwoerer, & Rosen, 1989) which reflected confidence in attempting the specific task in the experiment. Computer anxiety was directly related to performance outcome but the effect of self-efficacy was upon the way in which the task was attempted rather than upon the outcome. The researchers suggested that resistant computer users could be encouraged through enhancing their self-efficacy and that careful design of software could assist in that regard.

Prior exposure to multimedia materials was found to influence levels of self-efficacy for the use of multimedia training materials (Christoph, Schoenfeld Jr, & Tansky, 1998). Self-efficacy levels also influenced perceptions about the effectiveness of the training materials. Participation in the training tended to raise levels of self-efficacy but the researchers suggested that efforts should be made to raise self-efficacy levels before training commences in order to make the most effective use of resources.

As with self-efficacy for teaching, the concept of self-efficacy for computer use has proven to be a useful research tool. Each of several published scales has been shown to have acceptable validity and reliability and the choice of measurement should probably be made on the basis of suitability of the content of the scale to the context of use.

2.2.3.3 Self-efficacy for teaching with computers

The impact of teachers' beliefs on their behaviour in relation to computers has been consistently noted by researchers. In a study which sought to increase understanding of the reasons why UK primary teachers made only limited use of the computer, teachers identified as users (8 teachers), under-users (12) and non-users (8) were interviewed about the reasons for their decisions about computer use (Heywood & Norman, 1988). The findings revealed that the major causes of teacher concern were to do with competence and personal confidence about the relationship of the computer to on-going curricular activities. These results are consistent with other research which has found that teachers' skills in the personal use of computers do not necessarily translate into classroom uses. "Attitudes about technology or computers … are not the same as attitudes about teaching and learning with technology" (Laffey & Musser, 1998, p. 224). Hence, it seems likely that self-efficacy for computer use will be a necessary but not sufficient attribute of the computer-using teacher. This brings to mind the comment by Oliver (1994) about necessary and sufficient conditions for teachers' use of computers. If it is important to distinguish between the straightforward use of computers and their application in teaching, then a more specific form of self-efficacy, namely self-efficacy for teaching with computers, should be considered.

Various researchers have reported that teachers' decisions about whether and how to integrate computers into teaching have been affected by their pre-existing beliefs and practices (Miller & Olson, 1994; Novak & Knowles, 1991). Teachers' pedagogical beliefs, characterised as progressive (student-centred) or traditional, were found to influence their decisions about whether or not to use computers in their classrooms (Honey & Moeller, 1990). Special education teachers' uses of computers in their classes were found to be consistent with their general beliefs about classroom organisation and effective approaches to teaching (MacArthur & Malouf, 1991).

Marcinckiewicz (1994a) obtained measures of a variable he called "self-competence" in which respondents "rated their agreement with an item stating that they were capable of using a computer competently in teaching" (p. 229). His analysis found that this was the variable which best predicted computer use by teachers and he acknowledged that the "shared element between self-competence and self-efficacy is the person's expectation of competence in controlling their behaviour" (p.232).

Kellenberger (1996) developed an instrument to probe the self-efficacy of student teachers for working with computers in class. It comprised six items measured on a 5-point Likert scale from "not able or confident" to "very able or confident". Three items asked about future teachers' ability to influence students' effort, interest and achievement with computers. The remaining items referred to helping students' having difficulty with computers, challenging more knowledgeable students with respect to computers and making regular use of computers in class. The scale was used to investigate relationships among computer experience, perceptions of the value of computers and computer self-efficacy with a group of 222 student teachers. The strongest effects on the self-efficacy items were from perceived past success from computers and beliefs about the value of the computer for personal needs. These results are consistent with previous findings that self-efficacy is affected by experience and attitudes (Ertmer et al., 1994; Kinzie et al., 1994; Zhang & Espinoza, 1998).

Attitudes of student teachers about teaching and learning with technology have been investigated using a scenario-based attitude questionnaire (Laffey & Musser, 1998). Participants selected scenarios to match their responses to each of eight questions. Overall the data indicated that many pre-service teachers viewed computing as stressful and less relevant for traditional school outcomes than for problem solving or work environments. Although they see schools as slow to change, they accept that higher levels of computer use in schools are probably inevitable but they fear that computers will interfere with the teacher-student relationship.

The STEBI (Riggs & Enochs, 1990) was used as the basis for development of a Microcomputer Utilisation in Teaching Efficacy Beliefs Instrument (MUTEBI) (Enochs, Riggs, & Ellis, 1993). Factor analysis confirmed the existence of two factors which appeared to correspond to the outcome and efficacy expectations dimensions of self-efficacy theory and the reliability values of the scales were acceptable. The instrument was validated by comparing the results obtained with responses to questions about length of experience using computers in teaching and self-rating on a scale from non-user to expert. Both items were correlated significantly with the efficacy expectations sub-scale but neither was correlated with outcome expectations. The MUTEBI was used in the evaluation of a staff development program designed to encourage microcomputer use in science teaching (Borchers, Shroyer, & Enochs, 1992). That study demonstrated that when teachers' self-efficacy beliefs in their ability to use computers were increased through appropriate professional development they were more likely to incorporate computers into their teaching strategies.

Although there do not appear to be any other research studies which specifically link self-efficacy with computer use in teaching, several studies (Albion, 1996b; Downes, 1993; Handler, 1993; Summers, 1990) have identified low levels of confidence for teaching with computers as a factor influencing the levels of use of computers by student and beginning teachers.

Moersch (1995) noted that staff development for classroom integration of technology often assumed that participants can easily make connections between technology and curricula and that they are ready and willing to initiate changes in their instructional practices. He argued that neither assumption may be valid and that the failure of staff development to have the desired effect occurs because the intervention "neither reflects the instructional level of the teacher nor addresses fundamental self-efficacy issues" (p. 40).

Taken together, the studies referenced above point towards teachers' beliefs and, in particular, self-efficacy beliefs, being useful indicators of likely success at technology integration. Certainly the research provides sufficient reason to undertake further investigations in this area and to consider what approaches to teacher education and professional development might be effective in increasing self-efficacy beliefs for teaching with technology.

2.2.4 Changing teachers' beliefs

Kagan (1992) noted that changes in teachers' beliefs are seldom the result of reading and applying research findings. Teachers find most of their ideas from actual practice, largely from their own but also from the experience of their peers. She suggested that in order to promote professional growth in novices it would be necessary to first raise their awareness of their own beliefs and then to challenge those beliefs and provide opportunities to examine and integrate new information into their belief systems.

According to Richardson (1996), "perhaps the greatest controversy in the teacher change literature relates to the difficulty in changing beliefs and practices" (p. 110). She cited several studies where changes in student teachers' beliefs had occurred through socialisation and experience but noted that the results of studies of the effects of teacher education programs were complex. Studies of pre-service teacher education programs have reported mixed results, some observing changes in beliefs and others not. Inservice programs have generally been more successful in achieving changes and have demonstrated the importance of staff development that affects teacher beliefs for changing instructional practices. Richardson suggested that the limited success in pre-service programs might be related to lack of practical knowledge and the difficulty in helping students connect their beliefs to teaching practices. She recommended that additional exposure to teaching contexts through written and video cases, discussions with practising teachers and field work would assist in developing the practical knowledge required for programs to be successful in changing beliefs.

These recommendations from Richardson are consistent with the episodic nature of beliefs and their linkage to particular events (Nespor, 1987). Rather than developing through reflective and systematic study, "some crucial experience … produces a richly-detailed episodic memory which later serves the student as … a template for his or her own teaching practices" (Nespor, 1987, p. 320). As a consequence, Nespor argued that changes in beliefs were more likely to occur as a matter of conversion or gestalt shift rather than through careful argument.

Pajares (1992) noted that beliefs are most easily changed soon after they are acquired and that conflicting evidence is often reinterpreted as support for already held beliefs. Piaget's concepts of assimilation and accommodation can be applied to understanding changes in beliefs (Posner et al. as cited in Pajares, 1992). Minor changes in beliefs can be assimilated into the existing belief system. Major changes in beliefs require accommodation. Pajares listed four conditions (p. 321) which must typically exist before students will accommodate conflicting beliefs. First, they must recognise the anomaly. Second, they must believe that the new information should be reconciled with existing beliefs. Third, they must want to reduce the inconsistencies among beliefs. And fourth, they must see that assimilation has been unsuccessful. Pajares noted that this is consistent with the limited success of staff development programs in changing attitudes and beliefs unless teachers actually begin to change their practice. "Change in beliefs follows, rather than precedes, change in behaviour" (p. 321) which is consistent with the episodic nature of beliefs and the connection to critical events.

Studies which have sought to provoke changes in teachers' beliefs have confirmed the difficulty of inducing such change. A study, which tested whether the outcomes of training would be affected by congruence of training with pre-existing ideas or provision to trainers of information about participants' knowledge and beliefs, found that "beliefs exert a strong influence on knowledge acquisition" (Tillema, 1995, p.310). Tillema concluded that content-related beliefs are not easily changed through mere presentation of information but that challenging beliefs and stimulating cognitive conflict promised to be more successful as a means of restructuring teachers' knowledge. In a subsequent study with student teachers, application of a conceptual-change approach succeeded in producing a performance improvement in the use of a specific teaching technique but did not result in changes in student teachers' beliefs (Tillema, 1997). Tillema suggested that the solution might lie in increasing the intensity of exposure and prolonging the experience of programs aiming to change beliefs. In a study undertaken over an entire academic year which included university based teaching of theory, case studies and role plays, periods of practice teaching and the use of reflective journals throughout, student teachers were found to have integrated naïve prior beliefs with the theoretical content of the course (Brownlee, Dart, Boulton-Lewis, & McGrindle, 1998). The development in beliefs occurred in the stages after students had experienced both theoretical and practical components of the course and reflections on changes appeared to occur mostly during the university-based components. The researchers concluded that both university and practice teaching experiences contributed but that reflection was more likely to be possible in the periods when the time pressures of practice teaching were reduced.

2.2.4.1 Changing self-efficacy beliefs

Bandura (1986) described four principal sources of information which contribute to the development of self-efficacy beliefs: enactive attainment; vicarious experiences or observing the performances of others; verbal persuasion; and physiological states.

Actual performance of a behaviour (enactive attainment) is the most powerful source of efficacy information. Success increases the sense of efficacy and repeated failure lowers it. Once a sense of self-efficacy for a behaviour is developed, occasional failures will probably not decrease it. The significance of experience as a source of self-efficacy beliefs is consistent with the discussion of how beliefs change and with the research that has found relationships between experience and self-efficacy.

Seeing or visualising a similar person successfully perform a behaviour is the next best thing to doing it oneself and is the second most powerful source of efficacy information. Equally, watching a person of apparently equal competence fail will tend to decrease self-efficacy. That vicarious experience should be a source of self-efficacy information is consistent with the research studies that have reported the usefulness of access to role models for teachers (Albion, 1996b; Downes, 1993; Jones, 1998) and with the recommendations of Richardson (Richardson, 1996) for the use of cases.

Verbal persuasion, if realistic, can encourage efforts that are more likely to increase efficacy through success. Unrealistic expectations are soon corrected by unsuccessful attempts at performance. However, those persuaded of their inefficacy are likely not to attempt challenging activities or, if they do, are likely to give up quickly. Teacher educators are often very aware of the limitations of their persuasive efforts.

Because people use information from their physiological state to judge their capabilities, reactions such as fear and stress can affect self-efficacy. Teachers who are anxious about computers are liable to experience reduced feelings of efficacy as a result. Researchers have found that positive attitudes towards computers are associated with higher levels of self-efficacy for computer use (Kinzie et al., 1994). Such findings might be explained in terms of persons with positive attitudes towards computers being less likely to experience stress and a concomitant reduction in perceived self-efficacy for computer use.

Numerous studies have reported positive correlations between self-efficacy and some related behaviour. However, it is not always clear whether it is high self-efficacy which drives the behaviour or the successful behaviour which results in increased self-efficacy. Indeed, given the key role claimed for self-efficacy in human agency (Bandura, 1997) and the role of enactive attainment in developing self-efficacy (Bandura, 1986), it is clear that the two are in a relationship of mutual causality. Thus, it may be difficult to argue with confidence that an increase in self-efficacy is caused by actual performance and not vice versa. There is much less difficulty in claiming causality for vicarious experience or verbal persuasion since, although these may be correlated with increases in self-efficacy, they are unlikely to be caused by it.

There is an extensive literature concerned with the successful application of self-efficacy theory for therapeutic purposes (Bandura, 1986). However, little of it is directly germane to the topic of this thesis and this review will be restricted to research on self-efficacy in the areas of computing and teaching.

2.2.4.2 Changes in self-efficacy for teaching

Stein and Wang (1988) reported that there was a positive relationship between teacher success in an innovative program and perceptions of self-efficacy for implementing the program. Because their study included successive measures of the variables, they were able to observe that the improvements in implementation preceded the increase in self-efficacy and thus experience may have contributed to the increase in self-efficacy.

Gorrell and Capon (1988) measured student teachers' self-efficacy beliefs about teaching a particular skill before and after exposure to video tapes using two different instructional techniques. Cognitive modelling produced significantly greater increases in self-efficacy than did direct instruction. In a subsequent study, they found that cognitive modelling was superior for students with initial low self-efficacy but that for students with moderate initial self-efficacy there was no significant difference in the effects (Gorrell & Capon, 1989).

In a study conducted with graduate students undertaking a developmental course in college teaching, Heppner (1994) found that self-efficacy beliefs increased across the semester of instruction. When the graduates were asked to rate the importance of the four sources of efficacy information, all four appeared to contribute with the emphasis being on performance attainment and verbal persuasion in the form of positive feedback from students in classes they had taken.

In a more general context, research has found that peer models can be helpful with students who hold self-doubts about their performance. "Observing similar peers successfully perform a task can raise self-efficacy because they may believe that if the peers can learn, they can also improve their skills" (Schunk, 1987, p. 170).

The STEBI (Riggs & Enochs, 1990) has been used in several investigations of the development of self-efficacy for science teaching. Success in science courses, access to resources and time and support from colleagues and administrators contributed to increase in self-efficacy for science teaching in a study of elementary teachers (Ramey-Gassert, Shroyer, & Staver, 1996). Pre-service elementary teachers who participated in a cooperative field experience in which they watched several science lessons before planning and teaching a cooperative science lesson experienced significant increases in their science teaching self-efficacy (Cannon & Scharmann, 1996).

An Australian longitudinal study of changes in pre-service teachers' sense of efficacy for teaching science began by validating the STEBI for the local context (Ginns, Watters, Tulip, & Lucas, 1995). The instrument was used to collect successive measurements of self-efficacy of pre-service teachers during their course. Students who had successfully completed classes in both science content and methods were found to have significant increases in outcome expectancy as measured by one of the STEBI sub-scales, science teaching outcome efficacy (STO). That is, they were more likely to believe that teachers could improve science learning. However, there was no significant increase in their personal confidence to teach science as indicated by the other STEBI sub-scale which measures personal science teaching efficacy (STE). Data collected from interviews with students revealed that prior experiences related to the learning and teaching of science, especially recollections of their own schooling, influenced STE and that STO was increased by observation of the successful impact of science teaching on children (Watters & Ginns, 1995). In a subsequent study (Ginns & Watters, 1996), two students were interviewed during their first year of teaching after graduation. The interviews revealed that the effects of negative science-related experiences in their own schooling were still potent but that more recent positive experiences, including their university studies, had an impact and that both teachers' confidence for teaching science had benefited from effective support in their initial teaching appointments. These studies appear to support the view that self-efficacy beliefs are linked to personal experience and are difficult to change except through subsequent experience that provides strong evidence to contradict prior beliefs.

2.2.4.3 Changing self-efficacy for computer use

Gist, Schwoerer and Rosen (1989) reported on research in which managers and administrators undertook software training covering the same content but using either a tutorial or behavioural modelling as the instructional method. The dependent variable was software self-efficacy for use of the specific financial package. Behavioural modelling produced significantly greater increases in software self-efficacy for all participants. This result was consistent with Bandura's claim for the relative power of vicarious experience and verbal persuasion for increasing self-efficacy.

Smith (1994) found that self-efficacy towards using and learning about computers was increased through a combination of instruction and hands-on practice. The study also investigated the differential effect of verbal persuasion given in the form of two additional persuasive lectures but the results from this aspect of the study were inconclusive. The additional persuasion resulted in an increase in self-efficacy for females but not for males and it was suggested that the difference may have been related to the female instructor providing a role model for the females.

A reflexive approach, using electronic journals and technology portfolios in which students collected evidence of their technology use, was reported to have increased student teachers' self-efficacy for using computers (Kovalchick, Milman, & Elizabeth, 1998). The published report discussed the relevance of self-efficacy theory to teachers' use of computers and suggested that the technology portfolios contributed to an increase in self-efficacy by offering a means of documenting performance mastery. However, the paper reports neither the method used to measure self-efficacy nor any quantitative changes that were observed.

The effect of different goals and self-evaluation regimes on development of self-efficacy while working on computer projects was studied with a group of 44 US pre-service teachers (Schunk & Ertmer, 1999). The results indicated that providing students with opportunities for self-evaluation during task performance enhanced self-efficacy. The authors cautioned that self-evaluation could exert negative effects if students encountered serious difficulties but concluded that, in general, frequent self-evaluations are beneficial for enhancing self-efficacy.

2.2.4.4 Changing self-efficacy for teaching with computers

From the standpoint of self-efficacy theory, the ideal method for developing teachers' self-efficacy for computer use would be to provide them with training and support to work successfully with computers in their classrooms. Self-efficacy for computer use in science teaching as measured by the MUTEBI (Enochs et al., 1993) was increased through a professional development program which included workshops and on-site support over the course of a year (Borchers et al., 1992). The researchers found evidence that changes in self-efficacy were related to changes in behaviour and suggested that the effectiveness of the program was related to the ongoing support and the collegiality which was present among participants. In terms of Bandura's sources of efficacy information, the program appears to have offered a combination of successful performance supported by modelling and verbal persuasion from the ongoing support and collegial interaction.

Hannafin (1999) reported on a study conducted with twelve US teachers enrolled in a series of three courses on the integration of technology into the curriculum. The teachers ranged in age from 26 to 49 years and had from three years to 25 years of teaching experience. Two surveys were administered, at the beginning of the first course and at the end of the third. The surveys dealt with beliefs about school learning environment and with expectancies and values about learning to use and integrate computers. Although the measures were not explicitly identified as self-efficacy, they could be expected to tap related areas of beliefs. The content of the courses was intended to encourage teachers towards a more constructivist approach through using technology to design student-centred learning activities.

Although the students rated all three courses highly in evaluations and appeared to participate with enthusiasm and understanding, the anticipated shift in attitudes towards school learning environments did not occur. Hannafin concluded that the most plausible explanation was "that the students were not provided with opportunities to try out their learner-centred instructional activities they designed in real school settings. The content covered in the three courses was largely conceptual and theoretical" (p. 12). He suggested as an alternative, "more discouraging", interpretation that "teacher attitudes and beliefs are extremely difficult to change through education" (p. 12).

On the other hand, Hannafin reported that teacher perceptions about their ability to use and integrate computers improved, together with their perceptions of the usefulness of computers and their interest in computers. He commented on the dilemma implied by the findings on the two surveys. "Teachers like learning how to use computers and can become quite proficient without altering *how* they teach" (Hannafin, 1999, p. 13).

Hannafin's results provide additional confirmation, in a negative sense, of the research on change in teachers' beliefs. The nature of beliefs as described by Nespor (1987) and Pajares (1992) renders them difficult to change. When change does occur it is most likely to be in the context of practical experience rather than through rational consideration of concepts and theories.

A study of pre-service teachers engaged in field experiences with technology reported results which provide an alternative perspective (Balli, Wright, & Foster, 1997). This study drew upon the ideas of Calderhead and Robson (1991) in respect of student teachers' images of classrooms. The connection of images to beliefs has been argued by Pajares (1992). Through examinations of portfolios prepared by students during their field experience, the researchers found evidence that the experience had challenged the students' preconceived classroom images and aided their professional development, including increasing confidence in their ability to teach. Although this study did not relate directly to self-efficacy, it did provide additional evidence of the power of practical experience to impact belief systems of pre-service teachers.

2.2.5 Education for changing self-efficacy beliefs: Summary of theory and research findings

If it is desirable that teachers should integrate computers into their teaching, and if their success in doing so is affected by their beliefs, then one of the functions of a teacher education program should be to change beliefs in respect of teaching with computers. Specifically, since self-efficacy is a key determinant of behaviour, such a teacher education program might attempt to increase pre-service teachers' self-efficacy for teaching with computers. Given that aim, it is reasonable to look to self-efficacy theory and research for indications of the type of program that might be successful.

According to self-efficacy theory (Bandura, 1986), the most powerful source of self-efficacy information is successful performance. For practising teachers, the most suitable approach to increasing self-efficacy for teaching with computers might be to provide them with training and support while they integrated computers in their own classrooms. There is evidence that such approaches can work (Borchers et al., 1992). Such an approach has the added value of enabling access to suitable examples of successful integration and to ongoing encouragement. Building a collegial climate of support within a school should extend the effects of a program. The literature contains numerous examples of cases where the integration of computers by teachers appeared to be a product of the school culture (see, for example, Becker, 1994; Dexter et al., 1999; Dwyer, Ringstaff, & Sandholtz, 1991).

Increasing self-efficacy for teaching with computers among pre-service teachers presents a somewhat different set of challenges. The obvious parallel with practising teachers is to ensure that student teachers have successful experiences of teaching with computers during field experience. There is evidence that field experiences which emphasise the integration of technology can affect teachers' beliefs about working with computers in the classroom (Balli et al., 1997). However, there is strong evidence that students' effective encounters with computers for teaching during field experience are often of limited value or are even non-existent (Albion, 1996b; Downes, 1993; Jones, 1998, 1999). In practice, variations in the experience and expectations of cooperating teachers and in the availability of equipment make it impossible to ensure that all student teachers will experience the success that builds self-efficacy beliefs while working with computers in their field experience. No doubt some student teachers are able to work with exemplary computer-using teachers. However, on the estimate of Becker (1994) they will be a small proportion, no more than 5% to 10%, and other students will have experiences of variable quality. That is no basis for assuring a quality experience for all students.

If it is not possible to ensure that student teachers experience successful performance in teaching with computers, then the second most powerful source of efficacy information, vicarious experience, should be explored as an alternative. Again, the most obvious venue is field experience but the same difficulties arise as for providing students with direct experience in the use of computers for teaching. Students returning from field experience offer anecdotal comments about limited use of computers in the classrooms where they observed and the research on technology use in field experience has revealed a similar picture (Albion, 1996b; Downes, 1993; Jones, 1998, 1999).

Nor is it reasonable to assume that verbal persuasion will be sufficient to make the necessary difference. If experienced teachers with their own classes in which to implement new ideas were not persuaded by an extended educational experience (Hannafin, 1999), then it seems unreasonable to suppose that student teachers will easily be able to introduce new approaches to the use of technology during field experience. There is evidence (Novak & Knowles, 1991) that beginning teachers with control of their own classrooms find teaching with computers challenging even when they are wanting to do so.

It seems clear that there is sufficient reason for teacher education programs to seek means of increasing student teachers' self-efficacy for teaching with computers. However, it is equally clear that any attempt to accomplish this end through field experience will be beset by logistical difficulties. What is needed is a method of providing direct or vicarious experience in a manner which guarantees both its quality and its accessibility by all student teachers in a program.

2.3 Case methods in teacher education

Richardson (1996) suggested that the use of written or video cases might provide teacher education students with access to the practical knowledge necessary to support activities that seek to change their beliefs. This section will review some literature related to the use of cases and case methods in teacher education.

Explicit discussion of case methods in teacher education is a relatively recent discourse which has been thoroughly reviewed by Merseth (1996). This review begins by briefly examining the case for case methods using Merseth's review as the principal source. It then considers the relationship of cases to the development of expertise using sources from both the literature on teacher education and from more general studies of the nature of expertise and makes connections to the material about beliefs reviewed in the previous section. A search of the ERIC index and of the SITE and EDMEDIA conference proceedings and the related journals revealed a substantial literature describing the use of various forms of media to support the presentation of cases. Much of that literature simply describes the use of media in association with cases without either theoretical background or evaluation. In selecting studies for inclusion in this review, the focus was on providing a sense of the scope of activity and, where possible, its connection to relevant theory.

2.3.1 The case for case methods in teacher education

Over the past decade or so increasing attention has been given to the potential of case methodologies for teacher education. In reviewing casebooks published for use in teacher education, McAninch (1991) noted that interest had grown following the suggestion by Shulman (1986) that cases offered a valuable approach to representing knowledge about teaching and making it available for teacher education. Shulman (1986) identified three forms of teacher knowledge – propositional knowledge, case knowledge and strategic knowledge. He noted that propositional knowledge was economical in its expression but was lacking in contextual details which might assist its application in practice. Case knowledge was described as "knowledge of specific, well-documented, and richly described events" (p. 11). Shulman argued that "there is no real case knowledge without theoretical understanding" (p. 12) and that the use of cases in teacher education would promote development of the strategic understanding necessary for teachers to move beyond mere application of learned principles to the exercise of professional judgment.

A substantial review of cases and case methods in teacher education noted that cases have been used sporadically in teacher education for more than a hundred years although the present level of interest has existed only since the mid-1980s (Merseth, 1996). Merseth suggested that the interest might be driven by recent work on the nature of teachers' knowledge, the use of cases in other areas of professional education and the interest in reform of teacher education as a component of wider educational reform. In her view, cases have three essential characteristics. They are real, provide data for consideration and discussion by users, and they are designed to stimulate thought and debate. Cases should be distinguished from other types of materials such as "simulations, critical incidents and protocols" which "do not seek to bring a 'chunk of reality' into the classroom, nor … emphasize the unpredictability of a situation" (Merseth, 1996, p. 726).

Based on the material she reviewed, Merseth proposed that studies of cases in teacher education could be considered in three categories. In the first group, cases are approached as exemplars which are designed and used in ways that exemplify theories and techniques. In these cases priority is given to propositional knowledge. In the second group, cases are prepared as opportunities to practise analysis. These cases present situations from which theory emerges. The third approach to cases uses them to stimulate personal reflection, either through discussion of prepared cases or by having students write their own cases in response to their experience. Merseth noted that proponents of cases agreed that "cases appear to foster learning from experience, whether it is from their own experience or the experience of others" (Merseth, 1996, p. 729).

Carter and Unklesbay (1989) examined the prospects of using cases for teacher education in the light of experience in legal education where cases have been used extensively over many years. Cases for legal education are selected from an extensive case literature arising out of the customary method of recording legal knowledge, but cases for use in teacher education would need to be prepared specifically for that purpose. In addition to the practical difficulties of gathering material for cases, Carter and Unklesbay suggested that there would be ethical issues associated with the way in which teachers and their work may be represented. Other challenges to case development have been identified by McAninch (1991) who suggested that the limited adoption of case methods in teacher education may be due to lack of consensus over how teachers should approach their work and over what theoretical content teachers should know.

Empirical evidence of the effectiveness of cases in teacher education is limited. Merseth (1996) cited studies in which work with cases had resulted in changes in either "what" or "how" teachers think. According to those studies, cases had variously resulted in gains in the ability of students to understand and respond to cultural diversity, increased understanding of methods for motivating children, expanded pedagogical content knowledge in mathematics, and greater ability to analyse educational problems.

One empirical study investigated the effects of having students analyse the same case twice and whether case analysis was more effective before or after classes dealing with related theory (Lundeberg & Scheurman, 1997). Students consistently demonstrated more integration of theoretical concepts in a second analysis of a case. This was true not only for concepts studied in the unit immediately prior to the second analysis but also for concepts which had been studied in a unit prior to the first case analysis. The authors concluded that case analysis served as an anchor for conceptual understanding, thus supporting the use of cases before instruction in relevant concepts. Students reported viewing cases as authentic classroom problems. Reflection on case narratives appeared to promote transfer of knowledge across different subject areas, increased students' ability to frame problems of practice, and developed cognitive flexibility which was demonstrated by the use of varied perspectives. Students indicated that it was the case discussions which encouraged them to develop new perspectives. The authors concluded that the use of cases as anchors for instruction could increase learning of new concepts and that repeated analysis of cases was helpful in integrating theoretical and practical knowledge of teaching.

The limited empirical evidence for the value of case in teacher education is not surprising given the observation of Shulman (1992b) that in business, law and medicine where case-based approaches to professional education have been used widely for many years, there are no comparative evaluations to support the belief that such methods are more beneficial than lectures and discussions. However, if teacher educators are to invest the time and effort to develop and employ case materials, then it will be important to conduct further studies aimed at evaluating the value of case methods as alternatives or supplements to existing practices.

2.3.2 Relationship of cases to teacher expertise and beliefs

In the context of the present study, the interest in the application of case methods lies in their potential to influence the practice of pre-service or practising teachers through inducing changes to their beliefs about teaching with computers. There are at least two lines of reasoning which suggest that cases might have the necessary impact on teachers' beliefs and practice, namely, arguments from the nature of expertise and from the nature of beliefs.

2.3.2.1 Cases and expertise

Studies of expertise in various domains have suggested that experts seldom proceed by stepwise application of rules from a store of propositional knowledge. Dreyfus and Dreyfus (1986) argued that experts working in unstructured problem areas operate not by following rules but through non-conscious judgement based upon prior experience. In this respect they suggested that the performance of experts is frequently arational since it proceeds without the conscious analytic decomposition and recombination characteristic of thought processes which they identified as calculative rationality. However, they argued also that experts employ deliberative rationality in which, rather than analysis of a situation into context-free elements, the goal is to test and improve entire intuitions.

Several researchers have reported that experienced teachers appear to exhibit the characteristics of expert performance as described by researchers into expertise in domains such as physics and mathematics problem solving, chess, bridge and medicine. Berliner (1986) listed several characteristics of expert performance identified in research on expertise in other domains and for each provided examples of analogous performance by experienced teachers who participated in a series of studies which compared the performance of expert, novice and postulant teachers. In a study from the series which focussed on planning by teachers assuming responsibility for a new class, clear parallels were found between the ways expert teachers and experts in other fields process and store information (Carter, Sabers, Cushing, Pinnegar, & Berliner, 1987). The differences observed between expert and novice teachers supported the important role of experience in the development of expertise in teaching as in other domains.

In addressing the question of how managers might best learn business expertise, Dreyfus and Dreyfus (1986) argued that, since many of the elements important beyond the novice stage are situational, they are best learned through examples rather than by means of formal context-free definitions which may be counter productive since future situations may be similar but rarely identical. They proposed that skill acquisition, at and beyond the third of the five stages they identified in their description of the development of expertise, may be best served by construction of sequences of situational case studies. Such cases should include rich contextual information and should engage students in discussion and interpretation based on experience of previous cases and without a requirement for logical justification. Such an approach would depart from the conventional treatment of case studies using analytical problem solving.

Holyoak (1990) suggested that expertise might be developed through learning mechanisms that allowed some combination of direct problem-solving experience, instruction and exposure to solved examples. This view was supported by an earlier study in which students' learning from examples in relation to physics problems was marked by the generation of self-explanations which had the characteristic of adding tacit knowledge about the actions in the example solution (Chi & Bassok, 1989). It was found that students could learn with understanding from a single or few examples and that explanations could, in addition to instantiating a known principle, contribute to enhancing and completing students' understanding of the principles.

Studies of expertise have generally focused on well-structured knowledge domains, such as chess and physics, where the problems are clearly defined and there is an agreed solution. However, other knowledge domains may be classified as ill-structured. Such domains are characterised by conceptual complexity with problems typically involving simultaneous application of multiple perspectives and by across-case irregularity in which the pattern of conceptual interaction varies across cases which are superficially similar (Spiro, Feltovich, Jacobson, & Coulson, 1991b).

Cognitive Flexibility Theory (CFT) was proposed as a basis for promoting learning in ill-structured domains through "revisiting the *same* material, at different times, in rearranged contexts, for different purposes and from different conceptual perspectives" (Spiro et al., 1991b, p. 28). Merseth (1996) argued for the relevance of CFT to case methods in teacher education "because of its congruence with the 'ill-structured' nature of teaching" (p. 730).

2.3.2.2 Cases and beliefs

Interestingly, the ill-structured nature of the problems confronted by teachers was advanced by Nespor (1987) as a reason for the importance of beliefs in explaining teachers' behaviour especially when confronted by novel situations. Under such conditions, deductive reasoning is likely to be confounded by the difficulty of knowing which principles to apply. Consequently, knowledge that can be accessed from different perspectives acquires added value. Nespor argued that the episodic nature of beliefs made them more easily accessible in such circumstances.

The relationship of beliefs to teachers' particular experiences (Calderhead & Robson, 1991; Nespor, 1987; Pajares, 1992) means that beliefs are more likely to be changed through experience than through deductive argument from principles. Even so, changing beliefs is not easy and may require that the existing beliefs be confronted. Levin (1995) argued that discussion of cases was a critical factor in their contribution to the construction of knowledge because the discussions created disequilibria that led to assimilation and accommodation in students' thinking.

Research on teachers' beliefs (Richardson, 1996) and on cases in teacher education (Merseth, 1996) both point to the conclusion that access to practical experience through cases may be one of the most powerful approaches to changing teachers' beliefs and hence their practices. Decision-making cases for teacher education seek to represent the complex reality and ambiguity of teaching rather than provide exemplars as in medical education. This quality allows often unarticulated beliefs about teaching to be made explicit and open to reinterpretation (Lacey & Merseth, 1993). Teachers need to understand both that there are specific principles and techniques which are known to be effective and that "'thinking like a teacher' means creating their own knowledge in the face of indeterminate situations" (Merseth & Lacey, 1993, p. 283). Case-based methods preserve the complexity of teaching while permitting students to examine an event and bring to bear prior knowledge and experience as well as personal beliefs as they construct their own professional knowledge.

Pre-service teachers' cognitive growth was studied during a semester in which case studies were used (Lundeberg & Fawver, 1994). The results indicated significant improvements on all measures of cognitive growth and an increased tendency towards constructivist beliefs. Lundeberg speculated that the changes in beliefs were related to the narrative nature of both cases and beliefs and to the opportunities that case discussions provided for students to confront previous beliefs.

2.3.3 Presenting cases with media

Cases as described above are traditionally presented in the form of written narratives (McAninch, 1991; Shulman, 1992a; Silberstein & Tamir, 1991). Printed materials have the attraction of being relatively inexpensive to produce and distribute, and of being readily accessible without recourse to special equipment. However, the benefit of using audio or video content to enable students to access aspects of classroom experience have been recognised. Although there are differences of opinion as to whether protocol materials might qualify as cases (Kagan, 1993) or not (Merseth, 1992), they did provide a means for students to observe aspects of teaching which might otherwise have been inaccessible and used a variety of media including text, audio and video (Cruickshank & Haefele, 1987). In a study more closely related to case-based approaches, Copeland and Decker (1996) described the application of video-based cases to examining the way in which pre-service teachers make sense of classroom events. They found that topics discussed by students while working with the case materials were used by the participants to construct meaning from subsequent experiences.

From the use of audio and video content to supplement standard case materials, it is a relatively short step to the incorporation of cases into computer-based materials which incorporate a variety of media. Teacher educators have experimented with the use of interactive computer-based materials since at least 1977 (Strang, Landrum, & Lynch, 1989). Many of these materials would probably not qualify as "cases" in the usual sense of the term. However, some have been designed with the intention of bridging the gap between university classroom and field experiences and providing students with an "experiential history that enriches the impact of course readings, classroom lectures and discussions, and field observations" (Strang, 1997). Others presented students with scenarios which included student records, curriculum guides and other relevant materials, and required a series of decisions to be made about curriculum planning (McNergney, Lloyd, Mintz, & Moore, 1988). However, all of these examples were developed before multimedia systems became readily accessible.

The existence of common ground between case-based instruction and hypermedia was recognised by Merseth and Lacey (1993). They noted that promoters of both innovations regarded teaching as a complex activity which displays characteristics of ill-structured problem domains, valued learning in supportive groups, and recognised that learners bring their own preconceptions to the process of learning.

Hypermedia systems are well suited to the construction and presentation of materials which can support the approach to learning proposed by cognitive flexibility theory as suited to learning about ill-structured domains (Spiro et al., 1991b). Hypertext environments developed according to CFT have been reported to be more effective than alternative computer-based systems using drill and practice in promoting transfer of learning to new situations (Jacobson & Spiro, 1993). When compared to more traditional methods of presenting case materials, hypermedia offers advantages in the range of information types which can be included and in the flexibility with which teachers' experience, as illustrated in the case, can be linked with other experience and relevant theory. Such linkages are potentially important if the principles of cognitive flexibility theory are to be applied to development of electronic cases. Hence, the use of hypermedia for presenting cases might be seen as a natural progression and several projects which combine the two have been reported.

2.3.3.1 Interactive video cases

Video-based contextual materials for use in a mathematics methods course have been incorporated into a hypermedia system (Goldman et al., 1990). The material had previously been used as videotape but was transferred to videodisc for more flexible access. A computer program was developed to control access to the video material. Initially it was used by instructors but subsequently students were able to use it in small discussion groups for case-based practice. Students were observed during field experience and, compared to students in previous semesters who had not used the materials, they performed better on a range of classroom tasks. Theoretical support for the approach was drawn from studies of expertise in teaching and other fields (Goldman & Barron, 1990). The suggestion that learning can be facilitated by access to examples of expert performance appeared to be supported by the observation that "when video illustrations are used in the methods class to provide contexts for the topics studied and to demonstrate effective teaching techniques, students tend to incorporate these techniques into their own lessons" (Goldman & Barron, 1990, p. 28).

A subsequent report on related work (Goldman, Barron, & Witherspoon, 1991) dealt with the use of hypermedia cases as a means of engaging student teachers in analysis of examples of teaching. In this instance HyperCard programs were used to present the videodisc materials and to provide links to other information including bibliographies, comments from teachers or content specialists or contrasting video examples. The authors noted that the instructional approach did not "use a case method in the true sense" (p.29) but nonetheless it did illustrate the potential of the technology for this type of instructional use. While no quantitative results were offered to confirm improved learning by student teachers, the authors reported that students benefited from the analysis of the cases. Whereas students encountering mathematical information in a traditional lecture format methods course questioned its relevance, pre-service teachers analysing cases as presented in this study actually sought additional mathematical information to assist their understanding of the relevant principles.

Harvard, Day and Dunn (1994) described a videodisc system in which a library of teaching exemplars was categorised for retrieval using a barcode system. The criteria used to describe the exemplars were the same as those used for commenting on observations of student teaching. The system was intended to assist students in gaining situational understanding of classroom activities and the materials were designed to facilitate access to different but related exemplars.

A hypermedia tool developed to support flexible presentation of data from various sources was used to create literacy portfolios representing the work of school children (Reilly, Hull, & Greenleaf, 1992). These materials were used in exploratory studies with teachers who engaged in inquiry with the materials. The discussions provided windows onto teachers' beliefs which then became the basis for further discussion.

Cognitive flexibility theory was used as the basis for design of a system intended to enhance teacher reflection (Nelson & Smith, 1994). The system included prespecified cases, capability for entry of new cases by users and facilities for creating links between cases and from cases to theories. Although no quantitative results were published, the researchers reported promising results from field testing.

Lampert, Heaton and Ball (1994) adopted a principled approach to the conceptualisation and design of hypermedia cases. Faced with the difficulty of specifying the software for an untried approach to instruction, they began by trialing the case material using videotape and print materials rather than a computerised system. The case materials were well received by students and the experience was used to advance the design of computer-based case materials.

Video cases were used in three successive offerings of an educational psychology subject within a pre-service teacher preparation program (Hannah, 1995). Student evaluation produced positive responses which indicated that the video content helped students increase their understanding of course content and provided models for teaching and class management.

The use of multimedia to present video vignettes in the context of a course focusing on reflective practice has been described (Kenny, Covert, Schilz, Vignola, & Andrews, 1995). Within each of the several scenarios presented in the materials, the video vignette was played until a decision point was reached and the user selected one from three possible solutions. A video of the solution was played and followed by an expert analysis of the option which had been selected. The system also provided access to a library of relevant theories and to a commentary section where users could enter their own comments and access those made by other users. Student responses were positive and indicated that the materials had assisted them in developing a more reflective approach to teaching.

Cases including integrated media elements have been developed for use in elementary science teacher education (Abell, Bryan, & Anderson, 1998; Cennamo, Abell, George, & Chung, 1996). The materials were designed around the generative learning model of conceptual change in science teaching and comprised a series of videodiscs which illustrated classroom activities and teacher reflections. Use of the materials was facilitated by a computer program which enabled students to access video of various stages of the lesson process, background information about the schools and teachers in the cases and a reference library relevant to the concepts presented in the materials. During a semester in which the materials were used in conjunction with written and oral reflective tasks, observations found that students used the materials to analyse and re-examine personal theories, uncover visions of themselves as science teachers and frame classroom problems using collaborative reflection (Cennamo et al., 1996). Subsequently the materials have been used to construct a profile of pre-service teachers' images of themselves as science teachers (Abell et al., 1998). Design features which are claimed to have general application to the use of multimedia in case-based instruction include multiple representations of events through video and documentation such as lesson plans, selection of realistic cases which demonstrate development of events over extended periods of up to two weeks, presentation of a series of related cases, and provision for flexible use of the materials by individuals or groups (Cennamo et al., 1996).

Cognitive flexibility theory has been used as the basis for multimedia cases which have been developed to enhance teacher problem solving skills when dealing with students with emotional and behavioural disorders (Fitzgerald & Semrau, 1998; Fitzgerald, Wilson, & Semrau, 1997). The design of these materials was explicitly connected to principles described by Park and Hannafin (1993) and used videodisc for storage of audio and video content with control implemented by a computer program. Three case studies of children with behavioural disorders are included and users are able to observe the children in various situations, "interview" teachers and parents, seek information, compare and contrast multiple theoretical views, access expert discussion of the cases, and engage in problem solving and planning activities. Testing on two different sites revealed that the skills of the instructor and access to support for users of the materials had a significant effect on the outcomes. Analysis of data collected by interviews with the users, who were graduate students and practising teachers, found that the users had not altered their personal perspectives about meeting the needs of students with behavioural disorders but that there were significant changes in their ability to understand and synthesise multiple perspectives on problems (Fitzgerald et al., 1997). A subsequent study conducted with pre-service teachers found that there was significant learning on a range of measures including achievement scores, concept maps and quality of problem solving reports and that these changes were independent of student characteristics such as preferred learning styles (Fitzgerald & Semrau, 1998).

Most of the published reports of computer-based case materials tend to focus on the description of the materials and their development with some indication of student reactions to the materials and observations of the effects. It is relatively common for evaluations of such projects to fail to "provide meaningful evidence of student learning outcomes", relying instead on "feedback from students, peers and experts" (Bain, 1999, p. 165). The work reviewed above (Fitzgerald & Semrau, 1998; Fitzgerald et al., 1997) is one welcome exception.

Early instances of multimedia cases for teacher education used software on a computer to control an analog videodisc. Because this approach required the user to have access to a videodisc player and television as well as a computer, the materials were mostly used with large or small groups and were not readily accessible to individual students. As CD-ROM drives and Internet access have become widely available on personal computers, multimedia case developers have transferred their attention to those new media for presentation.

2.3.3.2 CD-ROM cases

Claudet (1998) described a project in which multimedia case simulations were developed for educational administrators. Initial trials found that the CD-ROM provided users with enhanced opportunities for individual and group learning and the performance profiles generated by the software assisted users to formulate professional growth plans. Users also appeared to internalise the process of reflective thinking and to engage in more reflective analysis of their own decision making after using the CD-ROM. The success of another simulation of educational administration was attributed to its ability to have students engage in the simulations as though they were real work (Maynes, McIntosh, & Mappin, 1996). Its design was based on experiential learning and incorporated various forms of interruption to better match the reality of administrative work. The authors argued that the simulation allowed the course to deal more effectively with issues that were not easily handled in either theory oriented classes or in internships which often involved only relatively trivial administration.

Another study which reported on a substantial investigation of the effects of hypermedia materials on pre-service teachers was that by Levin and Matthews (1997). The materials ran from CD-ROM and for each of five specific gender equity issues offered users a selection of five interactions which included background information and scenarios which presented questions and dilemmas for resolution. Video and animations were used to enhance the perspectives offered to users. Although the authors did not present the study as an example of a case-based approach, there are obvious similarities to the materials described in other studies reviewed above. Results obtained from trials with 51 students who took from 40 to 90 minutes to work through the materials indicated that there were positive differences for pretest and posttest measures of students' interest in, attitudes about and awareness and knowledge of gender equity issues.

Pre-service teachers working with commercially available multimedia multicultural materials recorded increases in their beliefs that ethnic diversity was an important characteristic in their future classrooms (Anderson, 1998). Students also reported increased understanding of learning theories, of cultural diversity and of the need for learning to deal with cultural differences in the classroom. The author noted that the lack of a control group did not permit a conclusion that the changes were due to the multimedia materials and that other aspects of the course may have contributed to the changes in students' attitudes.

Banks (1998) described a CD-ROM which featured virtual visits to the classrooms of five accomplished computer-using teachers with a focus on curriculum integration of software. In addition to video clips of entire teaching sequences in the selected classrooms, the CD-ROM included information relevant to teachers' planning for the lessons and samples of students' work produced in the lessons. Data from interviews conducted before and after teachers worked with the CD-ROM indicated that they had learned from the virtual visits and had begun to incorporate ideas into their own teaching. A similar approach to the creation of a CD-ROM to assist teacher educators in learning how to integrate technology has been proposed (Kurth & Thompson, 1998). Video footage collected in the classrooms of teacher educators who use technology will be used to create video cases which will serve as models and a focus for discussion by other teacher educators.

Several Australian examples of multimedia case-based materials have been described. A CD-ROM case study of an entire primary school was developed for use in a six to eight week unit of study (Walker, Lewis, & Laskey, 1996). The materials included video of the school and its community, interviews with teachers and students and a variety of documents. The intent was to provide students with opportunities to improve their capacity for making judgements in relation to the professional work of teachers. No evaluation of the impact of the materials in use was reported. Anchored instruction and cognitive flexibility informed the design of a CD-ROM which presented the work of an expert teacher for use in a teacher education program (Brown, Knight, & Durrant, 1996). Design and development was described but changes in staffing and course structure and failure to devise teaching strategies in parallel with the development of the materials resulted in no systematic evaluation being reported. Chambers and Stacey (1999a; 1999b) reported the development of multimedia cases for teacher development in computer use and in mathematics teaching, but again no report of the evaluation of the materials has been published as yet. Herrington and Oliver (1999) reported on analysis of patterns in teacher education students' thinking while working with multimedia materials developed for mathematics education using a situated learning framework. Using observations of student talk, they found that the majority of their thinking was higher-order and that social, procedural and lower-order talk was present in relatively lower proportions. They concluded that multimedia materials based on situated learning could encourage substantial levels of higher-order thinking.

2.3.3.3 Networked cases

Because discussion is an important element of the case method (Levin, 1995), the application of multimedia cases has typically involved group discussions. However, it is possible to use electronic networks to facilitate discussion of cases by groups who may not be able to meet physically because of constraints of place and time. The relative ease of use of the World Wide Web (WWW) has led to its becoming the most commonly used Internet service. In one study (Angeli, Supplee, Bonk, & Malikowski, 1998) pre-service teachers used a WWW conferencing system to present and discuss cases based upon their observations during field experience. In this instance the case presentations were restricted to text. However, other projects such as CaseNET (Bronack & Kilbane, 1998) and the Multimedia in Science and Technology (MUST) project (van den Berg, 1998) have used the WWW both to present multimedia cases and to facilitate discussion among pre-service and practising teachers. Neither study reported any results from their use of the case environments. More recently the addition of "learning routes" to MUST to provide guidance for users as they work through a case has been described (Nieveen & van den Berg, 1999).

2.3.4 The potential of multimedia cases

Merseth (1996) characterised cases and case methods as offering "a particularly promising possibility for teacher education" (p. 722) for which, on account of the newness of the field, there was, as yet, little empirical evidence. Computer-based cases share these characteristics and, being an even newer development, have even less solid empirical evidence of their value. One of the more cogent lists of potential advantages of multimedia cases was provided by van den Berg:

> 1 Stimulate an active learning attitude in a learner-controlled environment;
>
> 2 Yield the possibility to revisit classroom events in order to make sense of them;
>
> 3 Show the cases from myriad perspectives;
>
> 4 Offer procedural support for instructional design and classroom teaching;
>
> 5 Lessen the gap between theory and practice, by giving practice a more profound and integrated position in teacher education programs. (van den Berg, 1998)

It is only in recent years that multimedia technologies such as digital video, CD-ROM and WWW have matured to the point that hardware which will support development and playback is affordable and accessible to many teacher educators. The acknowledged potential for teacher education of cases, and of multimedia as a means of presenting them, makes it likely that there will be considerable resources directed towards development of multimedia case materials. Hence, there is a need for careful studies that evaluate the effectiveness of various approaches to the design of multimedia case materials for teacher education.

2.4 Problem-based learning

In the search for modes of instruction which might be successful in changing self-efficacy beliefs, case methods were considered initially because of their obvious relationship to the vicarious experience which is the second most powerful source of self-efficacy information (Bandura, 1986). On the basis of the research reviewed above there appears to be reasonable evidence to support the use of case-based instruction as a means of changing teachers' beliefs and in particular their self-efficacy beliefs for teaching with computers.

Compared to traditional written cases, computer-based cases which include multimedia elements may be especially useful because of their capacity to present more realistic information about the cases and to encourage increased engagement of the learners as they interact with the materials. Among the studies of multimedia case materials reviewed in the previous section there were several which based the design of the materials on variations of the traditional case format. References were made to cognitive flexibility theory (Fitzgerald et al., 1997; Levin & Matthews, 1997; Nelson & Smith, 1994), situated cognition (Bronack & Kilbane, 1998; Kenny et al., 1995), anchored instruction (Kurth & Thompson, 1998) and cognitive apprenticeship (Angeli et al., 1998). It is reasonable to ask whether these, or some other approach, might contribute more power to the design of multimedia materials.

Williams (1992) considered case-based instruction in the context of related approaches to instruction, namely, cognitive apprenticeship, which emphasises social contexts of learning, and anchored instruction, which uses problem contexts to increase the perceived relevance of learning. In doing so, she identified the case-method as used in legal and business education and the problem-based learning approach used in medical education as two examples of case-based instruction.

This section reviews literature relevant to assessing the potential of problem-based learning (PBL) as an approach to designing case-based interactive multimedia. The development of problem-based learning in the context of medical education has resulted in the related literature being concentrated in the medical education literature although much of what has been published there describes the practical application of PBL without adding much to an understanding of its working. Searches in the ERIC database locate a significant number of references related to PBL but few which deal with combinations of PBL and either teacher education or multimedia. For the purpose of this review, general articles about PBL were included if they went beyond the merely descriptive in attempting to develop an understanding of the operation of PBL. In considering PBL in teacher education and the use of computers in association with PBL there were much smaller bodies of literature and the criteria were relaxed to include more descriptive material.

2.4.1 The nature of problem-based learning

According to Barrows (1986), there are many varieties of problem-based learning which may be distinguished according to whether the problems provide the necessary information or require students to assemble it through free inquiry; the degree to which learning is directed by the teacher or the learner; and the sequence in which problems are offered and information is acquired. His taxonomy identified six variants of PBL and placed lecture-based cases, in which cases are presented in a lecture to illustrate points, at one extreme. At the other extreme are the problem-based approaches in which the problem is given, without additional data, as a stimulus and students engage in self directed learning to define the problem and locate necessary information. The case method is towards the middle of his taxonomy.

> What distinguishes PBL from other problem-centered methods, such as the case method, is that in PBL the problem is presented first, before students have learned basic science or clinical concepts, not after. Most proponents would also

> agree that PBL problems differ from the typical case history in that they do not (initially) provide or synthesise all the information needed to solve the problem; thus they provide greater realism and free inquiry. (Albanese & Mitchell, 1993, p. 53)

A more fine-grained 11 step continuum of problem-based learning has been proposed (Harden & Davis, 1998). It extends further in both directions than Barrows' taxonomy, beginning with *theoretical learning*, characterised by lectures or textbooks, and running through to *task-based learning* where the learning takes place in the real world of practice. The intermediate points represent additional variants of the forms described by Barrows (1986).

Using Barrows' taxonomy for simplicity, it is interesting to lay out the forms of PBL along a continuum. Lecture-based cases are not too far removed from pure lectures which exemplify *teaching as telling*. At the other end, problem-based learning approaches the *learning by doing* mode of real experience.

The three most important sources of efficacy information (Bandura, 1986) can be directly aligned with this continuum, matching *verbal persuasion* against *teaching as telling* at one end and *enactive attainment* against *learning by doing* at the other with *vicarious experience* matching the *case-based methods* in the middle. Figure 2.1 illustrates these alignments.

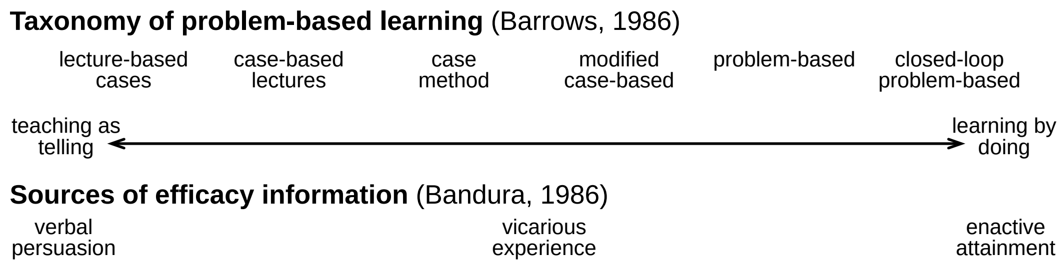

Figure 2.1: Taxonomy of PBL compared to sources of efficacy information

From Figure 2.1 it appears that, just as case methods are expected to be more powerful than lectures for increasing self-efficacy, problem-based learning approaches should be more powerful again. Hence, it is reasonable to consider more closely the nature of problem-based learning and whether it might form the basis for more powerful designs of multimedia materials intended to increase teachers' self-efficacy for teaching with computers.

2.4.2 Background to problem-based learning

Problem-based learning (PBL) had its beginning in medical education at McMaster University in the mid-1960s (Norman & Schmidt, 1992). It was developed in response to concerns that a focus on academic disciplines might not be the most effective preparation for future professionals (Boud, 1985). Since PBL first appeared, it has spread to many countries and different fields of professional education including, nursing, engineering, law and business (Boud & Feletti, 1991).

According to Schmidt (1983), the rationale for PBL included addressing the perceived irrelevance of some knowledge which students had to acquire in traditional medical curricula, the lack of integration of subject matter from different disciplines, the need for an orientation towards continuing professional education, and the desire to prepare students who could make appropriate use of their knowledge in professional practice. In developing his taxonomy of PBL, Barrows (1986) listed four objectives which he claimed were not well addressed by other educational methods but might be achieved through PBL. They were structuring of knowledge to support practice, developing effective clinical reasoning, developing self-directed learning skills, and increasing motivation for learning. The capacity of various educational methods to address these objectives formed the foundation of his taxonomy of PBL (see Figure 2.1).

PBL does appear to have been successfully implemented in a variety of contexts. A meta-analysis was conducted on the English-language international literature from 1972 to 1992 on the effectiveness of PBL in medical education (Albanese & Mitchell, 1993). The pooled findings indicated that, compared with conventional instruction, PBL is more nurturing and enjoyable for students and teachers, and that PBL graduates perform at least as well on clinical examinations but may be less well prepared on basic sciences. Ryan (1993) studied students' perceptions related to self-directed learning in a nursing course which used PBL and found significant changes in perceptions of both the importance of, and personal ability for, self-directed learning. Thus it appears that PBL may be achieving its major objectives in respect of preparing students for the realities of professional practice.

Schmidt (1983) argued for the success of PBL on the basis of its implementation of three key principles of the information processing approach to learning, namely, activation of existing knowledge when learning begins, encoding of retrieval cues with learned information and elaboration of knowledge through immediate application. Schmidt provided examples of how each of these is typically accomplished in PBL and described some preliminary results of experiments which supported his claim that PBL successfully applied the information processing principles.

A more recent paper examined the psychological basis of PBL in light of the research evidence from medical education (Norman & Schmidt, 1992). It concluded that there was no evidence to support claims that PBL resulted in any improvement in general problem solving skills although there was some evidence that PBL enhanced transfer of concepts to new problems and the integration of basic science concepts into clinical problems. PBL appeared to sometimes reduce learning initially but over longer periods encouraged increased retention of knowledge and appeared to contribute to improved motivation and skills for self-directed learning.

Neither the theoretical foundations of PBL nor the reports of research on its effectiveness have offered direct comment about any relationship between PBL and students' beliefs. The research on PBL has mostly been in the area of medical education where there is a strong focus on students' knowledge of medical science and its applications and little apparent emphasis upon beliefs and attitudes except as they impinge directly upon medical practice. However, the absence of explicit evidence for changes in beliefs and attitudes does not necessarily imply that such changes have not occurred. Increased motivation (Norman & Schmidt, 1992) is likely to reflect changes in students' attitudes. Improved perceptions of ability for self-directed learning (Ryan, 1993) and improved performance in clinical problem solving (Norman & Schmidt, 1992) are most likely associated with increased self-efficacy for the relevant activities. The absence of direct evidence of the impact of PBL on students' beliefs and attitudes is most likely a consequence of that evidence not being explicitly sought. Hence, there is reason to examine further the characteristics of PBL and how it might form the basis for design of multimedia materials for increasing self-efficacy.

2.4.3 Characteristics of problem-based learning

The process of PBL typically follows a sequence described by Boud (1985). Following the presentation of a problem, students work in small groups to analyse the problem and determine what information might be required for a solution. Once the necessary areas of learning are identified, students undertake individual study and research before returning to the group to share their findings and apply them to develop a solution to the problem. The final phase involves reflective activity in which what has been learned is summarised and integrated with students' prior knowledge.

A variation has been described in which the first phase involved individual rather than group work (Gibson & Gibson, 1995). Teacher education students were presented with a one page printed scenario describing a situation typical of the beginning years of teaching and were required to analyse the scenario and develop three alternative plans for action with projections of the likely consequences of each. The individual responses were later shared with tutorial groups and collaborative solutions were sought.

Whatever the nature of the field and its problems or the sequence of learning activities, PBL implementations appear to share some common characteristics. In creating a framework to facilitate analyses of educational approaches claiming to be PBL, Charlin, Mann and Hansen (1998) first identified three core principles of PBL. These were that the starting point for learning should be a problem, that the implementation should be an educational approach rather than a sporadically used technique in a traditional program, and that it should be a learner-centred approach. To these they added four principles related to the effect on learning:

1. learners are active processors of information;
2. prior knowledge is activated and new knowledge is built on it;
3. knowledge is acquired in a meaningful context;
4. learners have opportunities for elaboration and organisation of knowledge.
   (Charlin et al., 1998, p.324)

An alternative characterisation is that offered by Bridges (1992) who identified five characteristics of PBL:

1. The starting point for learning is a problem (that is, a stimulus for which an individual lacks a ready response).
2. The problem is one that students are apt to face as future professionals.
3. The knowledge that students are expected to acquire during their professional training is organised around problems rather than the disciplines.
4. Students, individually and collectively, assume a major responsibility for their own instruction and learning.
5. Most of the learning occurs within the context of small groups rather than lectures. (Bridges, 1992, p. 5-6)

Although it is not mentioned in either of these sets of PBL characteristics (Bridges, 1992; Charlin et al., 1998), the role played by the tutor is often considered in descriptions of PBL (Schmidt & Moust, 1998). They "do not serve as dispensers of information. Rather, they serve as resources to the team and provide guidance and direction if the team solicits assistance or becomes bogged down" (Bridges, 1992, p. 7).

Because, after the selection and presentation of a problem as the first step, the involvements of groups and tutors are so important to the operation of PBL, it is appropriate to consider in more detail what the research on PBL has revealed about those roles.

2.4.3.1 Role of the group in PBL

PBL is one of several educational approaches which have been characterised as *constructivist*. Indeed, according to Savery and Duffy (1995) PBL is one of the best exemplars of a constructivist learning environment. They characterise constructivism in terms of three primary propositions, two of which hint at the potential importance of groups in constructivist learning. First, learning is stimulated by cognitive conflict or puzzlement and exposure to the ideas of others in a group is one significant source of such stimuli. Second, knowledge evolves through social negotiation which is commonly facilitated through collaborative groups. Thus, theory suggests that the role of the group should be significant in the operation of PBL.

The acquisition of factual knowledge in PBL is thought to occur according to the principles of the information processing approach to learning (Schmidt, 1983). In this framework, small group discussion might be expected to contribute to activation of relevant prior knowledge and to offer opportunities for elaboration at the time of learning. Several studies have provided experimental confirmation of these mechanisms (Norman & Schmidt, 1992).

Schmidt (1993) reviewed research related to PBL and reported that there was evidence of problem analysis in small groups having a strong activating effect on prior knowledge and of elaboration by group discussion increasing understanding of relevant information. A study by Moust et al. (as cited in Schmidt, 1983) found that the quantity and quality of contributions made to the discussion were not related to achievement and suggested that students who were silent were engaged in "covert elaboration" (p. 429). This is consistent with the finding by Levin (1995) that teachers' thinking was as likely to be influenced by listening to the interactions in a group involved in discussion of cases as by direct involvement in the discussion. An investigation of students' thoughts during PBL discussions found that up to 75% of thoughts were task related (Geerligs, 1995). Thus, even when students are not overtly engaged in the group process their beliefs may be affected by covert thoughts about the topic of discussion.

A study of PBL group discussions using stimulated recall found that there was clear evidence of conceptual change which resulted from cognitive conflict when students were required to deal with facts and theories introduced by other students (De Grave, Boshuizen, & Schmidt, 1996). Again, this is consistent with changes in the thinking of teachers working on cases being caused by internal conflicts where ideas they heard contradicted or extended their own thinking (Levin, 1995). A more recent review of research on small-group processes in PBL (Schmidt & Moust, 1998) confirmed the benefits of small group problem analysis for facilitating understanding through activation of prior knowledge and for conceptual change resulting from initial problem discussion. Thus the claims for the importance of group processes for knowledge building through cognitive conflict and negotiation of meaning (Savery & Duffy, 1995) are supported by research although further research is needed to confirm these findings and elicit a fuller understanding of the contribution of group processes to PBL.

2.4.3.2 Role of the tutor in PBL

The role of the tutors who work with the small groups in PBL is facilitative rather than directive. Tutors are not intended to provide information but to model higher order thinking and to challenge the thinking of the learners (Boud, 1985; Savery & Duffy, 1995).

Nevertheless, there is evidence that the subject matter expertise of tutors can make a difference to student performance. In a study, in which PBL groups were tutored by staff members or by advanced undergraduate students, it was found that students guided by a staff member scored significantly higher on a test of higher order cognitive skills than students guided by a student tutor (Moust, de Volder, & Nuy, 1989). There was no quantitative difference in tutor behaviour as measured by tutor functioning scales. The researchers concluded that the greater subject matter expertise of staff members may have resulted in their interventions being more relevant.

In his introduction to a special issue of Instructional Science, Schmidt (1995) summarised the findings of three papers dealing with the role of the tutor in PBL. He noted that students tutored by staff tutors generally perform better than those tutored by peers; that student tutors display better understanding of the difficulties faced by learners but that staff tutors make more extensive use of subject matter expertise; and that staff and students favour student control over discussion. Both students and staff valued the tutor as a role model for critical thinking and reflection while students emphasised the importance of subject matter expertise in tutors.

A review of small-group processes in PBL (Schmidt & Moust, 1998) outlined a theory of tutor performance based on research. The key concept was "cognitive congruence" or a tutor's ability to understand and express ideas at the students' level of knowledge. This, in turn, appeared to be dependent upon the tutor's possessing both relevant subject matter knowledge and an authentic interest in students' learning. Effective tutoring in PBL appears to imply three qualities, namely, possession of a suitable knowledge base, willingness to become involved with students, and skill to express ideas in language understood by students.

2.4.4 PBL in teacher education

Compared to other professions, teacher education appears to have been little affected by PBL until relatively recently. Chappell and Hager (1995) reported that, although, in addition to medical education, "professional courses around the world, including nursing, design, engineering, optometry, architecture, law and business" (p. 2) were using PBL approaches, they were aware of no instance where this was occurring in teacher education. It is not possible to know how widely they searched or what criteria they used for inclusion. Certainly prior to 1995 there were conference papers (Dockett & Tegel, 1993; Gow & Levi, 1992; Tegel & Dockett, 1994) and a book (Bridges, 1992) which might reasonably be thought to refute their claim. Since that time, further reports of PBL use in teacher education have appeared although, in comparison to many other professional areas, the numbers are still modest.

Graduate programs in education which have reported the use of PBL include a pre-service masters program (University of Sydney, 1999), masters (Bridges, 1992; Cordiero & Campbell, 1996; Dimmock & Edwards, 1996; Tanner & Keedy, 1995) and doctoral (Limerick, Clarke, & Daws, 1997) programs in educational leadership and administration, and a masters award in information and learning technologies (Grabinger & Duffield, 1998). Reasons for adoption of and approaches to PBL varied. A program implemented in the hope of increasing the perceived relevance of the course to the real world of administrators reported at least partial success (Tanner & Keedy, 1995). Others reported initial struggles in the transition to having students accept more responsibility for their own learning (Dimmock & Edwards, 1996; Limerick et al., 1997).

At the undergraduate level, PBL has been incorporated into areas such as curriculum planning (Gibson & Gibson, 1995), early childhood education (Dockett & Tegel, 1993; Tegel & Dockett, 1994), science education (Peterson, 1993; Peterson, 1997), technology and design

(Williams & Williams, 1997) and computer integration (Hill & Hannafin, 1995; Ritchie, Norris, & Chestnutt, 1995). One study reported issues in adjustment to PBL with students enjoying group work but not seeing it as a means of learning (Williams & Williams, 1997) but another reported that students preferred having more control over their work, were more motivated and saw group work as a valuable component of the work (Peterson, 1993). Benefits reported for use of PBL included development of students' pedagogical reasoning skills and subject matter knowledge base (Peterson, 1993), increased confidence in students' own ability for critical and reflective thinking (Tegel & Dockett, 1994), and greater understanding that educational problems are ill-structured, seldom have a single correct answer and that there may be several reasonable alternatives (Dockett & Tegel, 1993; Tegel & Dockett, 1994).

One study of particular interest used a "problem-centred, activity-based" approach to teaching pre-service teachers about integrating technology into teaching (Hill & Hannafin, 1995). The teaching approach was not described by the authors as PBL, but as an Open-Ended Learning Environment (Hannafin, Land, & Oliver, 1999; Land & Hannafin, 1997). Students worked individually or in groups to solve problems which were used to introduce the technologies in the course but there were also presentations by the instructors. In the evaluations, students consistently reported increased confidence and reduced anxiety about using computers in teaching. The implication appears to be that the process of working to solve problems related to technology integration can increase confidence (self-efficacy) for its use in teaching.

It is not entirely clear why PBL has been less widely adopted in teacher education than in other professional courses. The enthusiasm for case-based approaches in teacher education is relatively recent and has tended to be associated with the case method familiar to law and business education (Carter & Unklesbay, 1989; Merseth, 1996). Perhaps this has resulted in that terminology being used to describe a wide variety of approaches, some of which might properly be regarded as falling towards the PBL region of Barrows' (1986) taxonomy. Whatever the reason, the results from the PBL studies reviewed here are encouraging and the use of PBL in teacher education warrants further investigation.

2.4.5 Computer assisted PBL

Hoffman and Ritchie (1997) identified a number of challenges posed by the implementation of PBL. Their list included reliance on written or verbal cases which may not adequately prepare students for dealing with problems which present in other forms; limitations on the numbers of problems of particular types accessed by students; initial adjustment problems of students inexperienced with self-directed learning; and management of learners who progress at different rates. They suggested several ways in which interactive multimedia might be applied to alleviate the problems they identified. These are summarised as follows:

fidelity – use of multiple modalities to overcome limitations in written or oral problem descriptions by providing visual and auditory cues;

representational richness – increased richness of interconnection of ideas through repeated exposure to material as described by cognitive flexibility theory (Spiro, Feltovich, Jacobson, & Coulson, 1991a) in relation to ill-structured problems;

time and timeliness – random access to components in multimedia systems supports students need for "just-in-time" information with greater flexibility than access to real experts;

individualisation – multimedia systems can be constructed to present variations of basic problems according to the entering characteristics of students;

assessment – computer systems offer opportunities for monitoring student progress and simulated contexts may permit testing of performance that would not be readily or safely accessible in reality;

efficiency – use of algorithms and templates for preparation of multimedia representations of problems (Ritchie et al., 1995) may save time for instructors and students, or templates may provide guidance and progressive disclosure of information through stages of a problem; and

increased power of agency – multimedia systems enable access to problem contexts which are not available in the classroom and at the same time provide guidance at critical junctures.

Hoffman and Ritchie concluded by offering challenges for multimedia designers to develop systems which could extend and enhance PBL curricula. They suggested that the characteristics of PBL environments (Savery & Duffy, 1995) provided a sound basis for design of multimedia PBL environments and that careful design might enable the computer to handle some of the more routine support and scaffolding functions of a PBL tutor with a consequent opportunity to have tutors spend more time on less routine matters.

To date it appears that few have taken up the challenge to meld interactive multimedia and problem-based learning. However, in recent years there have been more reports of the application of computer technology in conjunction with PBL. It is possible to conceive of two basic approaches to using computers with PBL. One approach would be to use computers to support otherwise standard approaches to PBL. The second would be to develop software systems that incorporate PBL principles in the instructional design.

2.4.5.1 Computer support of PBL

An early application of computers to support PBL used the computer as a presentation vehicle for problems and access to relevant information (Martin & Prideaux, 1994). Sawyer (1997) argued that computers should not replace existing approaches to PBL but should be used for presentation of problems and related information. In an interesting twist, development of Computer Based Education (CBE) materials to introduce and teach the processes of PBL for use in more standard PBL activities has been described (Crawford, Martin, & Smith, 1997).

Given the significance of group interaction in PBL, it is understandable that applications of computers in PBL have followed the spread of the Internet. Pennell and Deane (1995) described the use of the World Wide Web to support PBL through access to information including an image and audio glossary. Computer mediated communication (CMC) has been used to support a problem-based approach to a nursing education course offered at a distance (Oliver & Naidu, 1997) and the use of videotaped lectures, e-mail and a web site enabled distance education students in a biotechnology course to have on-line PBL experiences (Mackenzie, Kitto, Griffiths, Bauer, & Pesek, 1997). In another trial of the WWW for PBL, students responded positively but the value placed by students on teacher input would require mechanisms to ensure that this was available before using the system with off-campus students (Oliver & Omari, 1999).

For the most part, the examples described thus far have used technology to support conventional PBL experiences or to extend their range by distance education. Some researchers have attempted more comprehensive approaches in which the PBL experience is scaffolded or mediated using technology. A Problem Solving Assistant was used to support teacher education students through access to research resources and a problem-solving heuristic (Ritchie et al., 1995). The Collaborative Learning Laboratory (Koschmann, Kelson, Feltovich, & Barrows, 1996) comprising seven linked computer work stations was designed to provide computer support for small group interactions in PBL and Ronteltap and Eurelings (1997) described the functional design of a computer system which incorporated both individual and collaborative learning environments for PBL.

2.4.5.2 PBL in instructional design for IMM

Each of the systems described above offered to facilitate and enrich the experience of PBL either in a classroom or at a distance. However, in each case the design was intended to support existing PBL methods and did not represent an attempt to employ PBL principles as the basis for design of multimedia. A few systems have attempted (or proposed to attempt) the latter approach.

The development of a CD-ROM incorporating principles of PBL and case-based reasoning for use in nursing education has been described (Naidu, Oliver, & Koronios, 1998). The materials would include video presentations of cases, simulated interviews with domain experts and additional resources. Students would first encounter the problem and work through a series of decision points with the ultimate aim of developing an action plan for management of the patient.

Multimedia materials such as *Researching Lake Iluka* (Harper, Hedberg, & Whelan, 1998) and *Exploring the Nardoo* (Hedberg et al., 1998) have been designed to support their use in teaching sequences using PBL approaches and their use in that fashion has been described. Both are based on simulations of natural systems and are capable of presenting a variety of problems for solution. Tools are provided within the software for collecting and manipulating data. These packages provide effective illustrations of some of the potential uses of multimedia for PBL (Hoffman & Ritchie, 1997). Although the materials appear to be well suited to use in PBL, the simulations around which they are based could be used to support other approaches to teaching.

Nuldén and Scheepers (1999) described the use of a prototype interactive multimedia method for presenting a vignette to a group in the problem definition phase of PBL. They found that, because the group worked through the interactive multimedia materials in a series of steps, students spent more time in the problem definition phase with consequent opportunity to develop better understanding of the problem. They proposed a three phase methodology for what they termed PIE (problem-based learning, interactive multimedia and experiential learning). Phase one involved the group working through the interactive case with facilitation by an instructor. Phase two provided for a period of up to a week for individual reflection on the problem. In the third phase students would meet with the instructor for feedback and discussion.

Computer-based simulation and PBL have been combined in a single system for use in medical education (Hmelo & Day, 1999). The study investigated the use of questions embedded within the simulation as a means of scaffolding student learning. Students responded positively to the materials although they did require time to adjust to the new methodology. The questions were successful in helping students focus on important clinical information but were less successful in focusing attention on the underlying science. The authors concluded that embedded questions have the "potential to scaffold students' learning from simulations by focusing their attention on important aspects of the problems as well as modeling the kinds of questions students need to be asking themselves" (p. 163).

Despite the recent interest, as evidenced by these studies, in the application of multimedia to PBL there does not yet appear to be any reported attempt to incorporate the principles of PBL within a comprehensive multimedia learning environment. Such an environment would certainly include presentation of the problem and access to a variety of relevant tools and resources. It might offer a degree of learner support and scaffolding in the problem solving process, and, depending upon need and mode of implementation, it might provide for communication within groups of students and with instructors. PBL appears to offer a powerful instructional design model and there would be value in testing its potential for incorporation in interactive multimedia.

2.5 Designing educational multimedia

This section reviews selected literature related to the design of educational multimedia in order to identify principles which might guide the application of PBL as a framework for multimedia development. By first establishing PBL as a constructivist approach the need to review a vast amount of literature dealing with other approaches to design is removed. Even so, there is a substantial body of recent literature about specific constructivist approaches to learning environment design but in the interests of brevity this review is restricted to articles which synthesise constructivist principles across varied methods or which deal specifically with PBL. Following this material, attention is given to some recent literature which addresses the nature of interactivity in multimedia, the problems inherent in achieving a level of user control that promotes optimal learning and the potential role of narrative in such an interface. So far as can be ascertained by searches of the ERIC database and the Internet, the material on narrative in multimedia represents the most current work in the field.

2.5.1 PBL as a constructivist methodology

The use of computers in education predated the emergence of interactive multimedia (IMM) and was initially based on the then prevalent educational theory which was objectivism (Phillips, 1997). At the core of objectivism is the belief that "the world is real, that it is structured and that its structure can be modelled for the learner" (Jonassen, 1991, p. 9). In this view teaching and learning are about transmitting and receiving knowledge which exists independently of the knower. The methodology of instructional design developed around this view and led to the production of computer-based education materials which may be characterised as instructivist.

More recently educational theory has moved toward constructivism which "claims that reality is more in the mind of the knower, and the knower constructs or interprets a reality from his or her perceptions" (Phillips, 1997, p. 20). In this view, education emphasises student learning and doing which results in the individual creating meaning from his or her experiences. A constructivist approach to the design of computer-based educational materials would entail the design of environments which the learner would use to construct knowledge.

Phillips notes that there is no absolute instance of either objectivism or constructivism but rather a continuum of positions between the two. Reeves (1992, as cited in Phillips, 1997) listed 14 pedagogical dimensions which represented different aspects of the objectivist-constructivist dichotomy. Examples include behavioural versus cognitive psychology, abstract versus concrete experiential value, extrinsic versus intrinsic motivation, high versus low structure and teacher-proof materials versus equalitarian facilitator role for the instructor.

Early approaches to instructional design derived from an essentially objectivist viewpoint and focused on a fairly narrow view of learning. More recently a variety of new approaches to instructional design have approached learning from a wider perspective. These diverse instructional theories are not in direct competition but fill different niches and may be complementary to each other. They allow for a choice to be made according to the needs of a particular situation (Reigeluth & Squire, 1998).

PBL falls toward the constructivist end of the continuum described by Phillips. Indeed, PBL has been proposed as the paradigmatic exemplar of a constructivist learning environment (Savery & Duffy, 1995). Hence, in seeking to identify principles which might guide the development of interactive multimedia problem-based learning (IMM-PBL) environments, it will be appropriate to set aside the literature related to objectivist approaches and restrict the review to that related to the design and development of constructivist learning environments. Before proceeding to that, however, it will be helpful to review briefly some general material about the application of interactive multimedia to learning.

2.5.2 Interactive multimedia and learning

Phillips and Jenkins (1997) described four strengths of multimedia in education. First, like video and television, multimedia is able to mix media such as images, sound and text, allowing the possibility of selecting the most appropriate method of presenting particular content. Second, IMM has an advantage over video or television in that it can permit a degree of user control that allows a user to take an individual path through the material. Third, IMM is suited to simulations which enable visualisation and better understanding of complex, dynamic or inaccessible processes, either in demonstration mode or in a form which students can access for private study. Fourth, the versatility of IMM allows it to support different learning styles. These characteristics give IMM the potential to be used as an instructional aid, in interactive tutorials or in reference works.

The impact of media on learning has been a subject of ongoing debate. Kozma (1994) referred to work by Clark (1983) who reviewed the results of comparative research on educational media and concluded that results which appeared to favour one medium over another were due, not to the medium, but to the method or content introduced with the medium. Kozma sought to reframe the earlier question from "*do* media influence learning" to "*will* media influence learning" (p. 7). He argued that the shift of emphasis in education from an instructivist to a constructivist framework made it appropriate to re-examine findings which had been based on a transmissive approach to education. Kozma cited two studies which reported increases in student learning when using multimedia materials as compared to control groups using other approaches and argued that the gains resulted from designs which made the appropriate match among media, method and situation. In response to Kozma, Clark (1994) noted that he and Kozma agreed that, to that time, there was no compelling evidence that media attributes influenced learning. "Media and their attributes have important influences on the cost or speed of learning but only the use of adequate instructional methods will influence learning" (Clark, 1994, p. 27).

This debate, and the associated search for evidence, has continued beyond 1994. A recent meta-analytical study (Liao, 1998) considered the results of 32 published studies in which hypermedia systems were compared with traditional instruction. The author concluded that the evidence indicated that "hypermedia instruction has moderately positive effects on students' achievement over traditional instruction" (p. 352). Most of the studies included in the analysis were post-1993 and most involved tutorial or simulation applications. Liao noted that studies using the same instructor for both treatments had higher effect sizes than those using different instructors and concluded that this indicated that "positive effects of hypermedia instruction over traditional instruction should not be confused with the uncontrolled effects of instructional method noted by Clark" (p. 354). It is doubtful that the debate about the effects of media is resolved and it may be preferable to consider alternative ways of looking at the issues.

In the 1994 debate, a third voice claimed that the "debate should focus less on media attributes vs. instructional methods and more on the role of media in supporting, not controlling the learning process" (Jonassen, Campbell, & Davidson, 1994, p.31). Using analogies from quantum physics and chaos theory, Jonassen et al. argued that it was not possible to accurately predict the effect of media or methods on a process as complex as learning and that the focus should not be on media as deliverers of content to a learner but on how media can facilitate the construction of knowledge by the learner. In their view designers should "examine the process of learning first, then the role of context and the kinds of environments and cognitive tools needed to support that learning" (p. 38). Only then should consideration be given to the media best suited to create the environments or tools.

In identifying first the desirability of increasing teachers' self-efficacy beliefs for teaching with computers and then the likelihood that problem-based learning offers a powerful means of achieving that objective, this review has implicitly followed the path laid out by Jonassen et al. It remains to identify the features that should characterise interactive multimedia materials designed to implement PBL.

2.5.3 Design of constructivist learning environments

Since the late 1980s there has been a succession of contributions to the development of theories supporting the design of constructivist learning environments, although, given the predominantly behaviourist mindset of computer-based education at the time, the earliest of these probably did not envisage application to the design of computer-based materials (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990; Brown, Collins, & Duguid, 1989; Collins, Brown, & Newman, 1989). However, more recent examples of constructivist theories for educational design have tended to view computer-based materials as a natural expression of their potential (Jonassen, 1999). Whether or not the advent of interactive multimedia influenced the movement towards constructivist approaches to design of computer-based educational materials, there has certainly been a parallel development in thinking about educational design and in the capacity of technologies to support the new designs.

Interactive multimedia is a comparatively recent and rapidly evolving means for communication of ideas. Its development has been compared to that of cinema which took some time to develop conventions and structures which were equally understood by film makers and audiences (Plowman, 1994). Despite its evident similarities to media such as film and television, and its relationship to earlier forms of computer-based education, interactive multimedia is arguably different from both. Recognising this difference, Park and Hannafin (1993) reviewed existing psychological, pedagogical and technological research and theory to derive principles for the design of interactive multimedia. They outlined twenty principles and related implications and concluded that, considering the differences between IMM and other technologies and media, "designers must expand their perspective to consider teaching and learning methods and models heretofore unfeasible or unavailable" (p.81).

Not all of the principles outlined by Park and Hannafin could be considered constructivist. For example, principles 3 and 4 read, in part, "… supplied organisation of concepts to be learned" and "knowledge to be learned needs to be organised …" (Park & Hannafin, 1993, p. 70). These comments imply a transmissive view more easily aligned with objectivism than with constructivism. Other principles such as 10 and 11 which refer to authentic contexts and multiple perspectives are more clearly related to constructivist approaches. Although possibly ahead of its time when first published, this is indicative of the eclectic approach favoured by many modern theorists. For example, Jonassen, a well known proponent of constructivism, wrote "objectivism and constructivism offer different perspectives on the learning process. To impose a single belief or perspective is decidedly nonconstructivist. Rather, I prefer to think of them as complementary design tools" (Jonassen, 1999, p. 217).

Constructivism, even as it relates to informing design of IMM, is consistent with Jonassen's stance and does not present a single, monolithic view. It is possible to identify some general principles and there are some cogent statements of these. However, there is also a diverse group of approaches to constructivist design for learning including situated cognition and cognitive apprenticeship (Brown et al., 1989; Choi & Hannafin, 1995; Collins et al., 1989; Palincsar, 1989), anchored instruction (Bransford et al., 1990; Cognition and Technology Group at Vanderbilt, 1990, 1992), cognitive flexibility theory (Spiro et al., 1991b; Spiro & Jehng, 1990), goal based scenarios (Schank, Fano, Bell, & Jona, 1993), open learning environments (Hannafin et al., 1999; Hill & Hannafin, 1995; Land & Hannafin, 1997) and problem based learning as described previously. There are some common threads to these approaches from which some general principles of constructivist design may be gleaned.

In discussion of PBL as an exemplar of constructivist learning environments, but without reference to constructivism in IMM, Savery and Duffy (1995) derived eight instructional principles from constructivism. These were:

1 Anchor all learning activities to a larger task or problem.

2 Support the learner in developing ownership for the overall problem or task.

3 Design an authentic task.

4 Design the task and learning environment to reflect the complexity of the environment they should be able to function in at the end of learning.

5 Give the learner ownership of the process used to develop a solution.

6 Design the learning environment to support and challenge the learner's thinking.

7 Encourage testing ideas against alternative views and alternative contexts.

8 Provide opportunity for and support reflection on both the content learned and the learning process.

Hannafin and Land (1997) acknowledged that recent advances in computers and related technologies had made student centred learning environments possible and feasible by providing the means to manage electronic resources. However, they noted that the variety of approaches to design of such systems had not allowed a general understanding of the role of technology to develop. Hence they sought to identify some foundations and common assumptions of student-centred designs.

They argued that, in theory, all learning environments, whether student-centred or not, are based on five foundations, namely, psychological, pedagogical, technological, cultural, and pragmatic. Differences in environments reflect differences in emphases in what is drawn from the foundations. Ideally the influences of the various foundations should be consistent for a particular environment. For example, student-centred software might fail in implementation because it is inconsistent with the traditionalist culture of a school or because pragmatic considerations such as timetables make access to equipment difficult. Hannafin and Land (1997) suggested that it is the underlying assumptions of a learning environment that determine how the foundations are operationalised and so affect the features and methods of the environment. Despite surface variations, they argued, technology-enhanced student-centred learning environments share the following common assumptions:

1 Instruction, traditionally operationalised, is too narrow to support varied learning requirements.

2 Understanding is best supported when cognitive processes are augmented, not supplanted, by technology.

3 Learning environments need to support the underlying cognitive processes, not solely products of understanding.

4 Understanding evolves continuously.

5 Individuals must assume greater responsibility for their learning.

6 Learners make, or can be guided to make, effective choices.

7 Learners perform best when varied/multiple representations are supported.

8 Knowledge is most meaningful when rooted in relevant, scaffolded contexts.

9 Understanding is most relevant when rooted in personal experience.

10 Reality is personally constructed via interpretation and negotiation.

11 Understanding requires time. (Hannafin & Land, 1997)

Hannafin and Land concluded that, compared to direct instruction, technology-enhanced student-centred learning environments represent alternative approaches for fundamentally different goals. Such environments are not a universal answer for education and other methods may be more appropriate for certain purposes but attention to the underlying assumptions of any form of instruction is necessary if it is to be successfully implemented.

Being learner-centred is one of the defining characteristics of PBL (Bridges, 1992; Charlin et al., 1998). Hence, the assumptions advanced above (Hannafin & Land, 1997) are relevant to the design and construction of IMM-PBL and should be accounted for in any detailed design proposal. However, there are other sources that offer principles or guidelines relevant to the design of IMM-PBL.

Koschmann et al. (1996) list six principles of effective learning and instruction together with a detailed account of how PBL conforms to each. These principles were used to guide the construction of their Collaborative Learning Laboratory in which seven networked computers were used to support small group processes for PBL. In brief the principles were:

Multiplicity – complex, context-sensitive knowledge requires multiple perspectives, representations and strategies.

Activeness – learners construct meaning through active participation in learning.

Accommodation and adaptation – learning occurs through appraisal, incorporation and/or modification of understanding.

Authenticity – learning is best done through engagement in the types of activities required and valued in the real world.

Articulation – learning is enhanced by opportunities to articulate new knowledge.

Termlessness – knowledge is subject to revision and learning is a lifelong process.

Jonassen (1997) described instructional design models for use in problem solving with either well-structured or ill-structured problems. He began by considering the different characteristics of well-structured and ill-structured problems, and the processes typically followed in developing solutions to such problems. Using those processes as a basis he outlined a six-step process which might be applied to the design and development of ill-structured problem-solving instruction. The steps were:

1. Articulate problem context.

2. Introduce problem constraints.

3. Locate, select, and develop cases for learners.

4. Support knowledge base construction.

5. Support argument construction.

6. Assess problem solutions. (Jonassen, 1997, p. 83-86)

A comprehensive model for the design of constructivist learning environments has been described only recently (Jonassen, 1999). According to the editor of the book, its major contribution was "the integration of much work in the constructivist arena into a coherent instructional framework (Reigeluth, 1999, p. 216). Jonassen represented his model as a series of concentric circles with the selection and presentation of an authentic, ill-structured problem at the centre. Moving outward through the circles he listed related cases, information resources, cognitive tools, conversation and collaboration tools, and social and contextual support.

Jonassen's model explicitly refers to and incorporates insights from many, if not most, of the references cited here. It represents a substantial foundation upon which to build an approach to the design of IMM-PBL.

2.5.4 Interactivity in multimedia

Although there seems to be fairly general understanding of what constitutes multimedia, the nature of the interactivity in IMM is less clear. Phillips and Jenkins (1997) opt for a simple statement that "the 'interactive' component refers to the process of empowering the user to control the environment usually by a computer" (p. 8). For recreational or information seeking activities, interactivity may mean that control of sequence, pace and attention is appropriately in the hands of the user rather than the designer but it is less clear that this is always desirable in educational IMM (Sims, 1998).

Sims (1999b) referred to the paradox of interactivity, which is portrayed by some as an integral and critical component of computer based applications and yet is regarded by others as ill-defined, deceptive and difficult to implement. Elsewhere, Sims argued that the conundrum exists because the perceived advantage of interactivity in computer-enhanced learning (CEL) is based on perceptions of teacher-learner communication whereas the reality is often little more than mouse-clicks and repetitive feedback (Sims, 1999a). He defined interactivity as referring to "those functions and/or operations made available to the learner to enable them to work with content material presented in a computer-based environment" (Sims, 1999a, p. 308). From a consideration of learning theories, the means by which they might be implemented, and the likely interactive constructs that would be manifested in a CEL environment, Sims developed a typology of interactivity from the perspectives of learners, content, pedagogy and context (Sims, 1999a). For each he was able to describe the focus of interactivity, the way(s) in which it might be implemented and the learning theories underlying that particular expression of interactivity. He concluded that his analysis provided a means of viewing interactivity constructs in educational multimedia as outcomes of educational research rather than technological imperatives.

An alternative analysis described interactivity in terms of three dimensions, namely, control, adaptation and participation (Sims, 1999b). Control of video presentation represented an early attempt to define interactivity which was progressively extended to encompass other modes of presentation. Adaptation referred to the extent to which a computer application responded to user input, often through menu selections or question-response-feedback sequences. Participation represented a shift from a focus on overt actions toward the effect on the learner in terms of learning. Further movements in this direction have considered interactivity for meaningful learning and interactivity as a form of communication between learner and computer (Sims, 1999b). An example of the latter is in the analysis of educational media in terms of a conversational framework (Laurillard, 1993). Sims (1998) referred to work on human-computer interface design which described a *gulf of execution* when the user knows what to achieve but not how and a *gulf of evaluation* when the system changes, usually in response to user action, but the user cannot understand what has changed or why. He cautioned that user interaction with the software was a precursor to interaction with the content and any disturbance in the former may have consequences for effective engagement with the content.

As noted above, it is not clear that unrestricted learner control is desirable in educational IMM. Paradoxically, although user-control is a characteristic of IMM and the learner may expect to have control, the very status of being a learner suggests that the learner may not know enough to be given full control (Laurillard, 1998). The evidence about learner control in IMM environments is mixed. In some cases it has improved performance but in other cases some users of learner controlled environments have not performed as well as those in a program controlled situation. The implication appears to be that learner control works best when learners have a well established understanding of the content domain (Lawless & Brown, 1997).

If a schema theory approach is taken to the design of IMM, then information will be tightly organised and users' access to material will be guided and constrained. Alternatively, if a highly constructivist design is used, the content will likely be less structured and users will be able to explore more freely (Lawless & Brown, 1997). A study which compared learning through linear and sequential computer-based instruction and thematically cross-linked hypermedia found that students using the linear approach achieved better on recall of content while those who used the hypermedia scored better in tests of higher-order skills such as application and transfer (Jacobson & Spiro, 1995). The issue of user control is evidently related to the nature of the learning that can be anticipated through the use of IMM.

Lawless and Brown (1997) described five levels of learner control in multimedia environments. *Browsing* offers least control and interactivity and typically occurs when learners have no specific goal and tend to take a random path though the materials. *Searching* is more interactive, involving a defined goal, and is typical of users of a multimedia encyclopedia or similar software. *Connecting* permits learners to create their own links between pieces of information in the system. *Collecting* enables material to be identified and extracted for reassembly into another artefact. The final level of control, *generative*, permits learners to contribute to the instructional database.

Studies of navigation in multimedia environments revealed at least three common profiles (Barab, Bowdish, & Lawless, 1997; Lawless & Brown, 1997). *Knowledge seekers* select logical sequences of screens and acquire information systematically. *Feature explorers* (or *resource junkies*) spend more time understanding how the program works and what kinds of material it contains than in gathering relevant information. The third group, *apathetic users*, seldom deviate from a selected path and appear to have no clear goal for their use of the system. Research also revealed that learners with limited domain knowledge and metacognitive skill experienced difficulty in building sequences of information within multimedia environments and, as a consequence, tended to learn less from the text than users with greater levels of initial knowledge of the content. The effect appeared to be related to lower levels of comprehension stemming from lack of prerequisite knowledge and a tendency to be distracted by surface features of the software (Lawless & Brown, 1997).

Thus, although a lack of imposed structure and greater freedom of control for the learner is perceived as a major feature of educational IMM, that feature may work against the learner's need to understand the message. A key feature of IMM has the potential to become a disadvantage if it simply results in a lack of structure which obscures the message and impedes learning (Laurillard, 1998). Achieving the appropriate balance between structure and freedom is a key element in the design of successful IMM environments for learning.

Structure in IMM presents another issue from a different perspective. Conventional computer programs and multimedia materials rely upon the designers anticipating the resources and actions likely to be required by a user and implementing them through explicitly coded instructions. If IMM is to be at all successful in permitting the user to access material with apparent freedom, then it will require sophisticated data structures and program coding which can provide a variety of alternatives for the user. Kirsh (1997) described the difficulty of accommodating modes of learning in which learners can explore, discover and pose their own questions when the information available in a self-contained environment and the paths by which it may be accessed must be anticipated in design and construction. He suggested that the solution might lie in providing sufficient scaffolding to guide learners in useful directions without predetermining their path through the material. However, he argued that there was need for "more open-ended models of coherence and narrative structure" (p. 81). An alternative approach to providing users with freedom of operation might entail more open learning environments with users accessing materials beyond the boundaries of the software environment and interacting with other persons outside the confines of the software.

Sims (1998) referred to work on interface and metaphor design and the use of devices such as roll-overs to support user interaction by indicating that an object in an interface is active. He also noted that IMM materials frequently provide an array of tools (scaffolding) to support learning or problem solving. However, he questioned whether the learner would have sufficient understanding to apply the tools effectively and asked what factors might "contribute to a learner being integrated into the *narrative* of an interactive presentation" (p. 629). Based on his considerations of interactivity, he offered the following conclusions about interactivity in computer-based learning:

1. The success of educational multimedia applications is based on effective communication resulting from interactions and engagement.

2. There remains much to learn about the impact of interactivity on learning within the context of computer-based applications.

3. Linking our current understanding of interactivity with narrative may provide clues to appropriate use of interactivity.

4. The impact and role of the user and designer as integral components of narrative is gaining prominence as an issue for multimedia developers. (Sims, 1998, p. 630)

Sims uses these conclusions as a base from which to explore the relationship of narrative to interactivity in educational multimedia. Narrative should be understood as referring to both the storyline, as represented in the materials, and the experience of the user. He notes that IMM poses a challenge to traditional definitions of narrative because it is interrupted by decision points which may give rise to different experiences depending upon the choices made by a user (Plowman, 1996).

The exploration of narrative form as a basis for structuring multimedia has particular relevance in the present study because of the already identified significance of related concepts such as personal experience, images and episodic memory in the construction of teachers' belief systems and the evident relationship of narrative to cases and case-based learning. Hence it is appropriate to review some of the research on narrative form in multimedia.

2.5.5 Narrative form in multimedia

In some respects multimedia at its present stage of development presents users with similar challenges to those presented to the audiences of early moving films. These arise because the conventions and structures of the medium are still developing (Plowman, 1994). At a superficial level, IMM may appear to be simply a combination of already familiar media. However, the interpretive skills that users bring from their experience of component media are not always sufficient to deal with a composite medium which is more than the sum of its parts. Users can be confused and learners appear to have difficulty making sense of at least some IMM without considerable teacher support (Plowman, 1996).

Observations of children working with four different IMM programs which presented self-contained lesson sequences revealed that the experience was highly fragmented with frequent transitions from short sequences of video to text, graphics, machine interaction or group discussion (Plowman, 1996). The narrative structure of IMM differed from other media because of the unique and frequently changing combination of stimuli, the integral group discussion or individual reflection required by the task-oriented materials, and the control that learners have over pace, activity and other elements of the experience. Plowman noted the key features of narrative as temporality, causality and linearity but commented that, in the early stages of IMM evolution, navigational complexity may disrupt the dynamic that pulls a learner through a linear text. Plowman maintained that IMM design needs to develop narrative forms which are sustainable through the interruptions necessitated by user interaction, especially in group learning. Strong narrative should "create global coherence, contribute to local coherence, and aid recall" (Plowman, 1996, p. 97).

Although Plowman's research was conducted with children, narrative structure has also been found to be an important characteristic of educational IMM when used by adults. Narrative mediated through segments of video assisted recall and understanding as well as providing a sense of context for IMM used in training (Stratfold, 1994). In another study of IMM training materials, story contributed to motivation and to memory for content at both detailed and general levels. Its use allowed transmission of cultural content messages and users appeared to relate the story in the IMM to personal experiences (Bielenberg & Carpenter-Smith, 1997).

Laurillard (1998) reported on research which arose out of questions about exploratory learning and, in particular, observations that "learners working on interactive multimedia with no clear narrative structure display learning behaviour that is generally unfocused and inconclusive" (p. 231). The research was conducted in the context of an IMM project about Homer and Ancient Greece. The IMM was derived from existing material presented in narrative media comprising mostly print with video and audio additions and directed towards students understanding a concluding synthesis.

In converting the materials to multimedia, one approach would have been to create a multiply-linked audio-visual database which, although an excellent resource for researchers, would pose difficulties for students in the absence of a narrative structure. To achieve a balance between students being able to explore the materials at will and providing a structure which would guide students in the direction of the course objectives, a design was developed in which the narrative line was exposed as a series of goals defining the investigations to be carried out on the materials. Each week of the course comprised a series of activities with guidelines for conducting them. At the same time students still had access to the complete database of materials. Other tools were provided to assist with study organisation, database searching and note taking. Feedback on activities was provided as model answers which were available only after the student had attempted each task.

According to Laurillard (1998), the design as described above achieved the dual goal of maintaining the original narrative line with its concluding synthesis but, by involving the student at each stage, created a greater involvement in the final analysis. "Exposing the narrative line from the start brings them (the student) in as participant in the development of the story, rather than recipient of it" (p. 238). Evaluation with students was generally positive although, even with the narrative line made explicit, students tended to seek structure from the printed materials. It was found that there was a delicate balance to be struck between giving enough sense of narrative structure to lend confidence to students without it seeming too directive.

Hilf (1997, as cited in Sims, 1998) distinguished four narrative structures: linear, in which the user is guided throughout; interrupted, in which the narrative is halted for some form of interaction; branching, in which the user selects from multiple paths; and object-oriented, in which elements may be controlled by a user and impact on other users. Sims noted that the branching narrative corresponded to menu selection and interrupted narrative resembled a tutorial program with question-response-feedback loops. The approach described by Laurillard (1998) appears to correspond most closely to the interrupted narrative.

In considering the application of narrative in case-based IMM, Bearman (1997) reported on an evaluation of an IMM product which found that longer interactions bound together by narrative can be much more acceptable to users than a series of short, unrelated interactions. She concluded that, in designing case-based IMM, it would be important to devise a narrative that will allow the interactions to arise logically from the flow of the story. Commenting on another evaluation in which users became engrossed in the narrative and seldom ventured to explore other aspects of the IMM, she suggested that narratives may be most appropriate with novices in a content domain. She identified aspects of narrative that paralleled the role of a tutor, namely, enlisting the interest of the student, reducing complexity of the task, directing the learning process and accentuating key features.

Bearman's work suggests that narrative can be a powerful influence on the user's experience of IMM. Plowman (1996) reported that the greatest disruption of narrative occurred at the foci of interactivity and suggested that those points should be considered in terms of how they could contribute to the unfolding narrative. That seems to have been the strength of the approach taken by Laurillard (1998). Perhaps making the narrative explicit served to provide students with a sense of continuity and ultimate closure beyond the point at which they were interacting.

Sims (1999b) extended his discussion of narrative and interactivity to consider theatrical performance. He noted that theatrical concepts such as roles, cues and performance are useful in understanding everyday human behaviour and wondered about the cues provided by IMM applications and whether learners are in some sense playing a role as they interact. Using this analogy, he suggested, that, if the structure of an IMM application is viewed as a performance, then the learner, playing a role, might become part of the narrative or performance. As noted above, Laurillard (1998) remarked on the exposure of narrative drawing in the students as participants in, rather than receivers of, the story. Sims suggested that "by using a narrative or story to define the performance in which the learner is participating, a logical and meaningful series of interactions can be employed" (Sims, 1999b,

p. 269). In the longer run it may be that such environments would be implemented in virtual reality but it may be possible to approximate the concept of interactivity through user as actor in a narrative using simpler forms.

2.6 Principles for the design of IMM-PBL: A synthesis of the research

As outlined in the first two sections of this chapter, the available research suggests that teachers' self-efficacy beliefs for teaching with computers may provide a key to increasing the successful integration of ICTs into teaching. According to theory, next to successful experience, the most powerful influence on self-efficacy beliefs is through exposure to examples of the relevant behaviour.

Research on case-based methods of instruction suggests that they provide a means of making available suitable exemplars to influence pre-service teachers' self-efficacy beliefs. Multimedia has the potential to make the cases more vivid and more powerful.

The available research indicates that problem-based learning, as a variant of case-based instruction, appears likely to be especially potent in changing self-efficacy beliefs because, compared to other methods using cases, it engages learners in activities which are a closer approximation to reality. Problem based learning is one of a group of educational approaches which are generally described as constructivist and the general principles of design of constructivist learning environments may be applied to the design of IMM using PBL as a framework.

A review of the literature related to the use of narrative in interactive multimedia suggests that the inclusion of narrative may enhance the capacity of learners to make sense of the materials. Additional benefits should accrue from the use of narrative in IMM which uses case methods such as PBL and which seeks to influence beliefs which are strongly connected to experience and episodic memory.

Bearing in mind the line of argument expressed in this brief summary, it is now possible to propose some principles for the design of IMM-PBL. For each statement of principle, an indication is provided of the research which supports its inclusion. The references to sources are intended to be representative rather than exhaustive. Additional sources of support for each statement may be found in the research reviewed earlier in this chapter.

Principle 1: Begin with an authentic problem.

Problem-based learning should begin with an authentic problem which is genuinely problematic for the learner and representative of problems found in professional practice (Bridges, 1992; Charlin et al., 1998). Other constructivist designs refer to anchors (Bransford et al., 1990), a mission (Schank et al., 1993), an enabling context (Hannafin et al., 1999), or ill-structured problems (Jonassen, 1999). The use of descriptive materials as a basis for learning is typical of case methods (Merseth, 1992) and has been recommended for development of expertise with advanced learners (Dreyfus & Dreyfus, 1986). Situating learning in the context of experience should increase the availability of that learning in future problem solving episodes and reduce the incidence of inert knowledge (Brown et al., 1989; Palincsar, 1989). Using experience as a basis for learning should increase its capacity to affect learners' self-efficacy beliefs (Bandura, 1986) since beliefs are thought to be stored in episodic memory (Nespor, 1987).

Principle 2: Incorporate relevant cases.

Learning from examples or cases, especially when accompanied by explanations, has been found to be effective for developing expertise (Chi & Bassok, 1989; Holyoak, 1990) and has been recommended as an approach to changing beliefs (Richardson, 1996). Working from cases is a particular feature of cognitive flexibility theory (Spiro & Jehng, 1990). Cognitive apprenticeship depends upon access to a suitable master who exemplifies the processes to be learned (Brown et al., 1989) and cases are recommended for inclusion in design for ill-structured problem solving (Jonassen, 1997) and in a general model of constructivist environments (Jonassen, 1999). Several researchers have reported findings which suggested that access to models or exemplars of good practice might be important elements in preparing teachers for teaching with ICTs (Albion, 1996b; Downes, 1993; Moursund & Bielefeldt, 1999; Ringstaff et al., 1996; Sherwood, 1993).

Principle 3: Represent multiple viewpoints.

Cognitive dissonance induced through group discussion of problems is an important feature of PBL (De Grave et al., 1996; Schmidt & Moust, 1998) and has been noted as a feature of teachers' learning through case methods (Levin, 1995; Lundeberg & Scheurman, 1997). Confrontation of existing beliefs is a critical step towards changing them (Nespor, 1987; Pajares, 1992) and presenting alternative points of view should challenge learners to examine their own knowledge and beliefs.

It is characteristic of ill-structured problems that there is no single correct solution (Jonassen, 1997; Voss & Post, 1988) and since teaching is an ill-structured activity, thinking like a teacher means personally creating knowledge in complex situations (Merseth & Lacey, 1993). In such situations beliefs may be more easily accessed than knowledge and the capacity to access the same memories from different perspectives is important (Nespor, 1987). Cognitive flexibility theory suggests that this capacity can be built through accessing the same cases using different pathways (Spiro & Jehng, 1990).

Principle 4: Stimulate activation and elaboration of knowledge.

Activation of prior knowledge to facilitate linking to new learning and elaboration of new knowledge through immediate application are key tenets of PBL (Charlin et al., 1998; Schmidt, 1983). Although these concepts are drawn from an information processing view of learning rather than typical constructivist frameworks, there is support for viewing different theoretical frameworks as complementary (Jonassen, 1999). The emphasis in constructivist systems on creating a context for learning (Bransford et al., 1990; Brown et al., 1989) and engaging students in activity (Schank et al., 1993) are directed towards similar ends.

Principle 5: Scaffold learner performance.

In conventional PBL, scaffolding is usually in the form of support from a tutor or facilitator (Boud, 1985; Savery & Duffy, 1995; Schmidt & Moust, 1998). Providing an interactive tutor in IMM through the use of intelligent systems may be an achievable goal for the future but it is not yet practical. Alternative approaches to scaffolding for PBL could include decomposition of problems into sub-problems (Savery & Duffy, 1995) or the inclusion of heuristic aids (Ritchie et al., 1995). Other approaches to constructivist learning also incorporate scaffolding as a key component (Bransford et al., 1990; Brown et al., 1989; Choi & Hannafin, 1995; Hannafin et al., 1999).

Principle 6: Provide a strong narrative line.

Navigation in multimedia environments can present difficulties for learners (Barab et al., 1997; Lawless & Brown, 1997), even to the point of obscuring the message by causing learners to focus on the mechanics of the software rather than the content (Laurillard, 1998). Providing a strong and explicit narrative structure can create coherence and support learning (Bielenberg & Carpenter-Smith, 1997; Laurillard, 1998; Plowman, 1996; Stratfold, 1994). It is desirable to design a narrative in such a way that the interactions fit logically (Bearman, 1997) and, with appropriate design, it may be possible to engage the learner as a participant in the story rather than as an observer (Laurillard, 1998; Sims, 1999b). The narrative nature of cases has been linked to their effects on beliefs (Lundeberg & Scheurman, 1997) which are understood to be stored in episodic memory and linked closely to recollections of experiences (Nespor, 1987). A strong narrative line has the potential to enhance both navigability and the effects of the IMM on beliefs.

Principle 7: Provide access to relevant information.

In conventional PBL students analyse the problem, determine what information is needed and then seek it out (Boud, 1985). Supporting students' information needs has been suggested as one benefit of multimedia for PBL (Hoffman & Ritchie, 1997) and was a feature of designs for computer supported PBL (Koschmann et al., 1996; Ronteltap & Eurelings, 1997). Jonassen (1999; 1997) has argued for the inclusion of information resources in constructivist learning environments and links to theory and other relevant materials are a feature of cognitive flexibility environments (Spiro & Jehng, 1990). The inclusion of information resources in IMM offers a level of convenience but does not preclude students going outside the materials in search for additional resources. Depending upon the design of the environment it may include links or references to external resources.

Principle 8: Encourage self-evaluation.

Providing learners with frequent opportunities for self-evaluation during task performance has been reported to lead to enhanced self-efficacy (Schunk & Ertmer, 1999). Cognitive apprenticeship provides learners with frequent opportunities to compare their efforts with those of the master (Brown et al., 1989), and goal based scenarios which include simulations facilitate frequent checking of understanding (Schank et al., 1993).

Principle 9: Support individual and collaborative learning.

Conventional PBL includes students working in groups for a substantial part of the process (Bridges, 1992) and computer supported PBL has typically included mechanisms to support group interaction (Koschmann et al., 1996; Oliver & Naidu, 1997; Ronteltap & Eurelings, 1997). PBL groups have been shown to effect learning through activation and elaboration of knowledge, and by stimulating conceptual change through cognitive dissonance (Schmidt & Moust, 1998). There is evidence that students who listen but do not overtly contribute to discussion in PBL (Geerligs, 1995) or case methods (Levin, 1995) nevertheless learn from the discussions through exposure to different perspectives.

IMM can be used by individuals or groups and it would be possible for PBL cases presented in IMM to be dealt with by groups of students in the conventional fashion. However, the trends towards flexible and distance education and the desire to encourage continuing learning by professionals make the possibility of providing PBL experiences to individuals attractive (Albion & Gibson, 1998c; Gibson & Albion, 1998). Careful design of IMM might enable it to offer at least some of the advantages of participating in a group as a listener by including materials that present alternative perspectives.

Chapter 3: Research questions & methods

In Chapter 1 the overall direction of this study was identified as an investigation of what form of professional education might be successful in preparing pre-service teachers for integrating information and communications technologies (ICTs) into their teaching. Through a review of the literature across several fields, Chapter 2 identified teachers' self-efficacy beliefs about working with computers as a potentially important influence on their behaviour in respect of computers. Case-based methods, specifically problem-based learning (PBL), were proposed as a promising approach to professional education and guidelines were derived for the design of interactive multimedia (IMM) which would employ the principles of PBL.

This chapter will clarify the focus of the project, delineate the research questions, outline the research plan and describe the methodologies used for data collection and analysis in the study.

3.1 Research focus

As outlined in Chapter 2, there is ample research supporting the contention that teachers' use of computers in their teaching is influenced by their beliefs about computer use. In some studies the beliefs have been specifically nominated as self-efficacy beliefs (Enochs et al., 1993; Kellenberger, 1996). In other studies they have been identified as confidence and personal competence relative to computers (Heywood & Norman, 1988) or self-competence for using computers in teaching (Marcinkiewicz, 1994a). Regardless of the terminology used by different studies, it is clear that teachers' beliefs about their ability to work with computers have a strong bearing upon their tendency to do so. Thus there is justification for considering self-efficacy for teaching with ICTs as a key point of influence for increasing the capacity of pre-service teachers to teach with ICTs (Albion, 1999d).

Self-efficacy theory (Bandura, 1977, 1986) identifies successful performance of an activity and observation of successful performance by an appropriate model, in that order, as the two most powerful sources of influence on self-efficacy. It is not always possible to offer learners opportunities to practise performance of an activity as a means of building self-efficacy. In such circumstances, case-based methods, especially those that are enhanced by media representations of an activity, may offer the most practicable approach to increasing self-efficacy through vicarious experience.

It was argued in Chapter 2 that one of the difficulties in preparing pre-service teachers to teach with ICTs lies in ensuring that they have suitable experiences during field experience in classrooms (Albion, 1996b; Downes, 1993; Jones, 1998). Moreover, modelling of computer use, whether by mentor teachers or others, has been found to have a positive effect on pre-service teachers' use of computers (Albion, 1996b; Sherwood, 1993; Trushell et al., 1998). Hence, if it is desirable to increase pre-service teachers' self-efficacy in relation to teaching with ICTs, then it is reasonable to consider media-enhanced case methods as a vehicle.

Multimedia materials have previously been developed and used in the preparation of teachers for working with ICTs (Chambers & Stacey, 1999b; Kurth & Thompson, 1998) although not with the explicit intent of affecting relevant self-efficacy beliefs.

According to Barrows' (1986) taxonomy of PBL, there is a continuum of methods within which PBL lies closer to real experience than does the case method. It was argued in Chapter 2 that this should result in PBL being a more powerful source of self-efficacy information than the case method.

Hence, the focus of this study becomes an investigation of the effects of interactive multimedia using problem-based learning as the underlying design (IMM-PBL) on pre-service teachers' self-efficacy beliefs for teaching with computers. Such an investigation would be impracticable without the availability of IMM-PBL with appropriate content. Thus the first stage of the study necessarily involves the design and development of an IMM-PBL package relevant to teaching with computers. The process of design and development is described in detail in Chapter 4.

3.2 Research questions

Having clarified the research focus of the study, it is possible to develop research questions to guide the investigation.

The process of designing and developing IMM-PBL materials gives rise to questions about the validity of the materials in terms of the view presented of the integration of ICTs into teaching and their interpretation of PBL. The first two research questions are directed to these issues:

1 How do the views of teaching with ICTs as presented in the IMM-PBL materials compare with the findings of research on teaching with ICTs?

2 How well do the IMM-PBL materials incorporate the characteristics of problem-based learning?

A further question arising from the design and development process relates to the user experience of the materials.

3 How do users react to the presentation and content of the IMM-PBL materials?

Research by others has suggested that other factors, such as pupil control ideology, may affect self-efficacy in respect of teaching (Enochs et al., 1995). There is also evidence that factors, such as age, gender, experience with computers, innovativeness, teacher locus of control, perceived self-competence in computer use and perceived relevance of computers to teaching, influence teachers' use of computers for teaching (Marcinkiewicz & Grabowski, 1992). It is also possible that there may be significant relationships among self-efficacy for teaching with computers and other self-efficacy beliefs such as those about teaching or more generally about the use of computers. In addition, independent of any effect on self-efficacy for teaching with computers, the use of IMM-PBL dealing with the use of computers in teaching might be expected to result in some learning about teaching with computers and about other aspects of teaching. Hence, the following research questions are proposed:

4 To what extent is pre-service teachers' self-efficacy for teaching with computers associated with other factors such as age, gender, innovativeness, pupil control ideology, attitudes towards computers, self-efficacy for computer use and self-efficacy for teaching?

5 What effect does working with the IMM-PBL materials have on pre-service teachers' perceptions of their knowledge and understanding of using computers in their teaching or of other aspects of teaching?

The ultimate research question to be answered in this study relates directly to the focus of investigation and may be stated as follows:

6 What is the effect of IMM-PBL materials on pre-service teachers' self-efficacy beliefs in respect of teaching with computers?

3.3 Research plan for the study

In the context of educational innovations, including IMM, evaluation is intended to support more rational decision-making than would otherwise be possible (Reeves, 1992a). It should occur in each of the major phases of a project, namely, design, development, implementation, and institutionalisation (Bain, 1999). Thus, although it is possible to make a conceptual distinction between design and development on the one hand and data collection and analysis on the other, in practice, aspects of either may occur in parallel. For example, data about user reaction to the materials should be collected and analysed sufficiently early in the overall process to allow it to inform the final design.

Reeves (1992b) argued that, if evaluation methods are tools to support decision-making, then they should be selected according to the nature of the decisions to be made or questions to be answered. The past couple of decades has seen a shift in evaluation techniques from traditional experimental and quasi-experimental approaches towards a "mixed method approach" combining two or more evaluation methodologies (Mulholland, Au, & White, 1998). Available methodologies include interviews, focus groups, questionnaires, observations, implementation logs, anecdotal records, ratings, expert review and tests (Reeves, 1992b). In this model evaluation becomes a process in which information is gathered from multiple sources using both qualitative and quantitative techniques. Interpretations and conclusions are arrived at through triangulation (Jones et al., 1996).

The approach taken in this study has been informed by these recent developments in approaches to educational evaluation. Hence, a mixture of qualitative and quantitative methods has been used depending upon the context in which data were being gathered and the purposes for which they were intended.

Table 3.1 offers an overview of the methods proposed for investigation of each of the research questions. As noted above, some aspects of data collection were to be undertaken during the design and development process with a view to informing that process. Other aspects of data collection and analysis were dependent upon completion of a working version of the IMM-PBL materials although in some instances pilot studies of instruments were conducted during the development process.

Table 3.1: Research questions and proposed methods of data collection

	Research question	Data collection methods
1	How do the views of teaching with ICTs as presented in the IMM-PBL materials compare with the findings of research on teaching with ICTs?	• Interviews of consultants (cooperating teachers)
2	How well do the IMM-PBL materials incorporate the characteristics of problem-based learning?	• Questionnaire answered by a PBL "expert" group
3	How do users react to the presentation and content of the IMM-PBL materials?	• Questionnaire answered by beta[1] testers • Questionnaire answered by a PBL "expert" group • Questionnaires answered by students using pilot and completed versions • Sample of journals kept by students using the completed version • Interviews with a small sample of students using the completed version
4	To what extent is pre-service teachers' self-efficacy for teaching with computers associated with other factors such as age, gender, innovativeness, pupil control ideology, attitudes towards computers, self-efficacy for computer use and self-efficacy for teaching?	• Questionnaires answered by students at the time of trials of the pilot and completed versions to include demographic items and scales for Attitudes towards Computer Technologies, Self-efficacy for Computer Technologies, teacher efficacy, pupil control ideology and innovativeness
5	What effect does working with the IMM-PBL materials have on pre-service teachers' perceptions of their knowledge and understanding of using computers in their teaching or of other aspects of teaching?	• Questionnaires answered by students at the time of trials of the pilot and completed versions • Sample of journals kept by students using the completed version • Interviews with a small sample of students using the completed version
6	What is the effect of IMM-PBL materials on pre-service teachers' self-efficacy beliefs in respect of teaching with computers?	• Pre-test and post-test measures on the Microcomputer Utilisation in Teaching Efficacy Belief Instrument to be administered to students working with the completed version

[1] In software development, a version in which all planned features are implemented for testing purposes is conventionally referred to as the *beta* version.

Approval for the research was sought and obtained from the University Research and Higher Degrees Committee at the project proposal stage and prior to commencement of data gathering. Participants in each data gathering activity were advised of the general nature of the research, that their participation was voluntary, that confidentiality of individual data was assured and that any results would be reported in summary form and without identifying information about individual participants.

3.3.1 Proposed schedule of research

Initially it was not possible to specify more than a broad outline of the materials to be produced. As the description of the materials was refined, the nature and scope of the project became clearer. When funding through the grant was notified in late 1996 it included an expectation of completion within approximately one year. Table 3.2 represents the approximate project schedule as envisaged at that time.

Table 3.2: Anticipated project schedule

Year	Month(s)	Activity
1996	Jan	Project conceptualisation and funding application
	Mar - Jun	Initial video shoot and editing; Further planning
	Dec	Notification of funding
1997	Jan - Sep	Development of content for inclusion
	Feb	Pilot testing of ACT and SCT scales
	Apr	Additional video production
	Jun - Sep	Selection of development environment Prototype development
	Sep	Prototype testing * Pilot testing of additional scales
	Oct	Design refinement
	Nov - Dec	Development of materials to beta version
1998	Jan	Beta testing
	Feb	Materials revision
	Mar - Apr	Evaluation trials; Data gathering

The schedule was maintained for most of 1997 but, as will be described below, difficulties emerged following the testing of the prototype. As a consequence, there were changes in personnel and substantial delays in development. Table 3.3 summarises key activities beyond the prototype testing.

Table 3.3: Actual project schedule after prototype testing (see * in Table 3.2)

Year	Month(s)	Activity
1997	Oct	Design refinement
	Nov - Dec	Minor revisions to prototype Dr Gibson relocated to the USA
1998	Jan - Mar	Continued revisions with limited results
	Apr	Development by the author of a demonstration version in HyperCard Discussions with programming team
	May - Jun	Development suspended due to the author's absence
	Jul - Aug	Decision to switch environment to web browser Programming team support restricted to minor component development (Shockwave[1]) Author assumed responsibility for project management and programming

Year	Month(s)	Activity
	Sep	Initial tests of conversion to web environment
		Refinement of storyboards for scenarios[2] 2 to 4
	Oct - Dec	Development and testing of web prototype with JavaScript programming
1999	Jan - May	Development of Shockwave[1] components by programmers Revision of project graphic design by artist Redigitising of video and audio components by technician Completion of beta version by author
	Jun - Jul	Beta testing
	Aug - Oct	Debugging and revision
	Oct - Nov	Preparation of CD master
	Dec	Delivery of completed CD-ROMs
2000	Jan - Apr	Evaluation trials Data gathering

[1] Shockwave refers to a process developed to compress multimedia content developed in a package such as Macromedia Director so that it can be delivered more rapidly across a network for viewing in a web browser.
[2] Each of the four problems developed for the IMM-PBL package was to be presented in the context of a scenario which included a fictitious narrative and contextual information about schools and people.

There were three key periods for data collection. These were at the prototype trial (October 1997), during the beta test period (June and July 1999) and in the evaluation trial period (February to April 2000). Validation of the design and content are treated separately since they do not belong to any of the three sets of procedures. Table 3.4 shows the schedule for administration of the various instruments and procedures.

Table 3.4: Schedule of data collection

Instrument or procedure	Validation	Prototype trial Oct 1997	Beta evaluation Jun - Jul 1999	Evaluation trial Feb - Apr 2000
PBL validation	X			
Content validation	X			
MUTEBI		X		X
ACT & SCT		X		X
PCI		X		X
Teacher efficacy		X		X
Innovativeness		X		X
User questionnaire		X		X
Heuristic evaluation			X	
User journals				X
User interviews				X

Where the analysis of data required statistical treatment, this was performed using SPSS 6.1 for Power Macintosh.

The remainder of this section will describe the methods used for collection and analysis of data to address the research questions advanced at the beginning of this chapter. Instruments and procedures will be grouped together for description according to the period in which they were first administered specifically for this study. Within those groups they will be described in the order in which they appear in Table 3.4.

3.4 Design and content validation

As should be evident from the description of the design and development of the IMM-PBL materials, various evaluation strategies were employed to ensure that the design adhered to the principles derived from the review of research and that the content was plausible and valid. The procedures identified in this section have been selected to provide a degree of formalisation of the evidence that, firstly, the CD-ROM represents a valid interpretation of PBL principles and, secondly, the content it presents is valid for the domain of integrating ICTs into teaching.

3.4.1 PBL validation

So far as could be ascertained from the review of the literature as presented in Chapter 2, the application of PBL as a design framework for IMM is novel. There seemed little doubt that the materials produced in this project would qualify as IMM. However, given that there is some debate as to what constitutes PBL (Barrows, 1986; Charlin et al., 1998) and that its implementation has generally involved groups of students meeting with a tutor, it seemed reasonable to seek data that would confirm whether the IMM-PBL materials were admissible as PBL.

Determining a basis on which a judgement about whether IMM-PBL is genuinely PBL presented a challenge. The criterion that was established was that IMM-PBL could be reasonably regarded as genuine PBL if it was recognised by a group of PBL practitioners as matching the characteristics of PBL.

Using sources from the PBL literature (Bridges, 1992; Charlin et al., 1998) nine characteristics of PBL were identified and stated in a form suitable for inclusion in a questionnaire. The characteristics were presented on a form where respondents were asked to rate the extent to which they agreed or disagreed that the materials incorporated the relevant principle or characteristic of PBL. Each characteristic on the form was accompanied by a rating scale ranging from 1 (strongly disagree) to 5 (strongly agree) with an additional rating of NA for "Not Applicable". Respondents were invited to use the space provided below each item for comments amplifying their opinion. The form also provided space for the respondents to identify themselves and to provide some indication of their experience with PBL.

In order to obtain an independent assessment of the implementation of PBL in the IMM-PBL materials, responses were sought from PBL practitioners who were not already familiar with the materials. An author of a significant paper about multimedia and PBL who was known to the present author but had not been consulted during the development was approached directly. In addition an e-mail message was posted to a PBL mailing list with a significant international distribution inviting members of the list to participate in the evaluation. The message included a URL where a version of the materials could be accessed from a web server and a second URL where the questionnaire was available as a form that could be completed on screen and submitted directly to the author by email.

The questionnaire is included as Appendix A.

3.4.2 Content validation

Both project directors and the research assistants were teachers with up to twenty years experience. As each element of content was collected or developed it was reviewed by at least two of these persons and one or more of the cooperating teachers. This process of frequent inspection by experienced teachers was the primary means of ensuring content validity.

It was always anticipated that the contributions of the cooperating teachers would be the most powerful content in the completed IMM-PBL package. User response to the prototype was especially strong for the video clips of teacher interviews with almost 70% of responses indicating the videos as the favourite element. Because the video received such a strong positive response from users it was selected for closer examination of the ideas it was conveying. The analysis was assisted by the fact that the interviews had already been transcribed for inclusion in the materials.

The method used to obtain the interviews, including the questions and transcription of the responses, is described as part of the materials development in Chapter 4. As a first step towards analysis, the transcripts of the interviews were read through twice. Once a basic familiarity with the content of the responses had been achieved, the transcripts were read again and annotated with a view to developing categories for analysis.

During the reading and annotating, constant comparisons were made both within the transcript of each interview and across the texts of interviews from different teachers (Dey, 1993). Categories were progressively refined until a consistent set of categories and sub-categories was obtained. Division of the texts into fragments was generally held at a coarse level, reflecting the intention of identifying key ideas rather than fine detail.

Each response was marked into segments and coded using the categories that had been developed through the analysis. Exemplars of the key ideas were identified and, where appropriate, the number of responses in particular categories was noted.

Using the annotated materials and exemplars, descriptions of the patterns and themes that emerged from the interviews were constructed. These descriptions were supported by exemplar passages from the interview transcripts.

3.5 Prototype trial

Trials with the prototype were planned with final year teacher education students who were studying the subject in conjunction with which the IMM-PBL materials were to be used in future offerings. It was anticipated that this group of students would provide the most valid indication of how the materials might be received by an equivalent group.

The semester schedule for these students had been modified to accommodate a lengthy field experience and there was a single week in which the trials could be scheduled. Because the rest of the university was on recess during that week it was possible to book a computer laboratory for most of the week and to schedule convenient times for students to work with the materials in two groups of about fifteen each.

Arrangements were made for the students to complete a battery of instruments before and after using the IMM-PBL materials. The intent was to conduct a complete pilot test with the instruments to be used in the final evaluation. The exposure of students in the prototype trials would be much shorter than in the implementation phase and was thought unlikely to produce significant differences on any of the instruments. The pretest instruments were administered on the Monday. Students were to work with the materials at scheduled times during the week and the posttest was to be administered on the Friday.

Windows NT systems were used for the prototype trial. Technical staff installed the software on a file server and ensured that the individual work stations were properly configured to run it. Students were supplied with headphones so that they could listen to audio without interference from neighbouring work stations. The project directors, research assistants, one of the programmers and a technician were available during the trials to assist students as necessary.

Despite repeated assurances from the programming team over the weeks and days prior to the trial, the software was not available until the final day on which laboratory sessions were scheduled. Hence only one group of fifteen students was able to work with the prototype. Moreover, the prototype included minor errors that rendered it impracticable for students to work through the prototype as they might through the completed materials. Hence, the trial focussed on obtaining students' responses to the various elements of the software. Both project co-directors were present throughout the trial to assist students as necessary.

As a consequence of the limited use of the materials the posttest was abandoned since it was unlikely to yield useful data. However, the planned user questionnaire to evaluate the materials was administered as students completed working with the materials.

Table 3.5: Instruments used in the prototype trial

Instrument	Pretest	Posttest
MUTEBI - Microcomputer Utilisation in Teaching Efficacy Beliefs Instrument	X	
ACT - Attitudes towards Computer Technologies	X	
SCT - Self-efficacy for Computer Technologies	X	
PCI - Pupil Control Ideology	X	
Teacher efficacy	X	
Innovativeness	X	
User evaluation questionnaire		X

Table 3.5 lists the instruments administered in association with the prototype trial. Other than the user evaluation questionnaire, which was developed specifically for this study, the other instruments have all been described and validated previously. Their salient characteristics and the rationales for their inclusion are discussed below. Scores were calculated as averages rather than as totals on the individual scales in order to facilitate comparisons of scales with unequal numbers of items.

Both questionnaires administered in conjunction with the prototype trial are presented in the Appendices. Appendix B represents the multi-instrument questionnaire administered before the trial. Appendix C contains the user evaluation questionnaire.

3.5.1 Microcomputer Utilisation in Teaching Efficacy Beliefs Instrument

The Microcomputer Utilisation in Teaching Efficacy Beliefs Instrument (MUTEBI) was developed to measure the self-efficacy beliefs of teachers as they relate to utilising microcomputers in science instruction (Enochs et al., 1993). Although it was derived from the Science Teaching Efficacy Beliefs Instrument (STEBI) (Riggs & Enochs, 1990) the items in the scale do not refer specifically to science teaching contexts and appear to be more generally applicable.

Both the MUTEBI and the STEBI, from which it was derived, include teacher self-efficacy (SE) and outcome expectancy (OE) items, consistent with the theoretical construct of self-efficacy (Bandura, 1986, 1997). The following items are typical of those comprising the relevant scales:

Self-efficacy example

> I understand computer capabilities well enough to be effective in using them in my classroom.

Outcome expectancy example

> If students are unable to use the computer, it is most likely due to their teachers' ineffective modelling.

The MUTEBI is presented as a five point Likert scale ranging from strongly disagree to strongly agree with the middle position as uncertain. Nine of the 21 items in the scale are negatively phrased and are reverse scored.

Factor analysis conducted on data from 197 science teachers in a large urban area in the USA confirmed that the items loaded as expected on two factors. Additional questions about teachers' use of computers in teaching were used to confirm the validity of the instrument. Reliability of the instrument was found to be .78 (alpha) for the OE scale and .91 (alpha) for the SE scale. The authors concluded that the MUTEBI was a valid and reliable instrument (Enochs et al., 1993).

The STEBI, from which the MUTEBI was derived, has been used in two forms. The original (A) version was developed for use with teachers. In the alternative (B) form the items have been varied to be more readily applicable to preservice students (Enochs & Riggs, 1990). Since the MUTEBI had been designed for use with teachers it was adapted for use with preservice teachers by modifying the wording of some items. The following items illustrate the changes:

Original form

When using the computer, I usually welcome student questions.

Modified form

When using the computer, I will usually welcome student questions.

Because the present study was conceived as a small scale evaluation of the IMM-PBL materials, the number of participants was not sufficiently large to support development and validation of a new instrument. Hence the MUTEBI, modified as described above, was selected as a suitable measure for use in this study.

3.5.2 Attitudes to computers and self-efficacy for computer use

Although "judgements of self-efficacy are task and domain specific" (Pajares, 1996, p547), it seems reasonable to consider whether there might be a relationship between self-efficacy for teaching with computers as measured by the MUTEBI and other measures such as attitudes towards computers, self-efficacy for working with computers and self-efficacy for teaching. Hence it was decided to obtain a measure of these variables from the participants in the present study.

The Attitudes towards Computer Technologies (ACT) and Self-efficacy for Computer Technologies (SCT) instruments (Kinzie & Delcourt, 1991; Kinzie et al., 1994) were reviewed in Chapter 2. The Attitudes towards Computer Technologies (ACT) instrument comprises two scales, one of 8 items measuring Comfort/Anxiety related to computers and the other of 11 items measuring Usefulness of computers. Each scale includes a balance of positively and negatively worded items which invite a response using a 4-point Likert format with descriptors ranging from strongly disagree (1) to strongly agree (4). Higher scores indicate greater comfort in the use of computers and more positive perceptions of their usefulness. Alpha reliability for Form B of the ACT was reported as .91 for the entire measure and .91 and .85 for the Comfort/Anxiety and Usefulness scales, respectively (Kinzie et al., 1994).

The Self-efficacy for Computer Technologies (SCT) instrument was developed and later modified to assess self-efficacy with different types of computer technologies (Kinzie et al., 1994). A 4-point Likert scale with descriptors ranging from strongly disagree (1) to strongly agree (4) invites responses to statements preceded by the phrase, "I feel confident", for example, "I feel confident making corrections while word processing." Form B of the instrument, as described by Kinzie et al., comprised 46 items measuring perceived self-efficacy for word processing (10 items), electronic mail (9), searching CD-ROM databases (6), use of spreadsheets (7), creation and management of databases (7) and use of statistical packages (7). Alpha reliability for the various scales ranged from .95 to .98.

A study conducted with teacher education students at USQ (Albion, in press) reported on the development of a slightly modified version of the SCT. The modification consisted of replacing the sub-scale relating to statistical software with sub-scales related to operating systems and the Internet.

Analysis of responses from 175 students in the first administration of the ACT and SCT confirmed the two factor structure of the ACT and found an alpha reliability of .86 for the entire 19 item ACT instrument. The reliability estimates for the individual scales were .90 (Comfort/Anxiety) and .71 (Usefulness). For the SCT an alpha reliability estimate of .98 was obtained for the entire 53 item SCT instrument. The reliability estimates for the individual scales were .96 (Electronic mail), .95 (Internet), .95 (Word processing), .91 (Operating system), .94 (Spreadsheets), .94 (Databases) and .92 (CD-ROM databases).

The scales used in this study were the original ACT and the modified version of the SCT (Albion, in press).

3.5.3 Pupil control ideology

A study conducted with 73 preservice elementary education majors at a university in the midwestern USA found that preservice teachers with higher science teaching self-efficacy scores also had more humanistic orientations towards classroom management (Enochs et al., 1995). However, the relationship between science teaching outcome expectancy and orientation towards classroom management, although in the hypothesised direction, was not significant.

The self-efficacy instrument used in the study was the STEBI. Orientation towards classroom management was measured using the Pupil Control Ideology (Willower et al. as cited by Enochs et al., 1995). The STEBI is closely related to the MUTEBI as proposed for use in this study. Moreover, various studies have suggest a relationship between teachers' use of ICTs and approaches to classroom management (for example, Honey & Moeller, 1990; Sandholtz, Ringstaff, & Dwyer, 1997). Thus there seemed to be reason to investigate the possibility of a relationship between the MUTEBI and PCI.

Enochs et al. (1995) used the original 20 item version of the PCI which was presented as a 5 point Likert scale ranging from strongly disagree to strongly agree. They obtained a Cronbach alpha reliability of .75.

The dimensionality of the PCI has been investigated with a sample of 199 primary and intermediate teachers from the central USA (Graham, Benson, & Henry, 1985). That study performed factor analysis and found that a 10 item, single factor version of the scale provided the best description of the data and recorded an alpha reliability coefficient of .71. This 10 item version was selected for the purposes of this study.

3.5.4 Teacher efficacy

As described in Chapter 2, there have been many studies of the construct variously referred to as teacher efficacy or self-efficacy for teaching. Most studies of teacher efficacy have used the instrument developed by Gibson and Dembo (1984) or variants of it. In a study of the construct dimensions of teacher efficacy, Guskey and Passaro (1994) modified the items used in previously published versions of the instrument to remove what they saw as anomalies in the wording of the items. Their instrument included 21 items presented on a six point Likert scale ranging from strongly disagree to strongly agree. In trials conducted with 342 prospective and experienced teachers in the USA they found that there were two dimensions. The first, the *internal* sub-scale, appears to represent perceptions of personal influence in teaching and learning. The second, the *external* sub-scale, appears to represent the influence of elements beyond the direct control of the teacher.

The instrument as published by Guskey and Passaro (1994) was selected for use in this study.

3.5.5 Innovativeness

A study involving 170 practising teachers and 167 preservice teachers in the USA found that innovativeness was a significant predictor of computer use for the practising teachers (Marcinkiewicz, 1994a). Hence innovativeness is of interest for its potential relationship to self-efficacy for teaching with computers and was selected for inclusion in this study.

The innovativeness scale used by Marcinkiewicz was developed through analysis of 53 items administered to 231 USA college students in a basic communication course (Hurt, Joseph, & Cook, 1977). Items were presented using a seven point Likert scale ranging from strongly disagree to strongly agree. The data were subjected to factor analysis and 23 items were selected for the final instrument. A subsequent study was conducted with 431 public school teachers in the USA. Factor analysis of those data confirmed the unidimensionality of the scale and resulted in a 20 item instrument with an alpha reliability of .94. The authors proposed a 10 item version using the items with the highest item-total correlation and good internal reliability (Nunnally's r = .89) and a correlation of .92 with the 20 item version.

For the purposes of this study, the 10 item version of the scale was selected.

3.5.6 User evaluation questionnaire

The goal of the prototype trial was to gauge user reaction and gather data that would assist in refining the design of the IMM-PBL materials. Hence the key instrument used in association with the trial was a questionnaire developed by the author in collaboration with the project co-director and the research assistants.

Appendix C represents the user evaluation questionnaire as used in the prototype trial. It comprised 37 items structured as shown in Table 3.6.

Table 3.6: Structure of prototype evaluation questionnaire

Items	Item type
1 - 20	5 point Likert scale, strongly disagree to strongly agree, with items about the materials
21 - 27	5 point Likert scale, much less to much more, in reference to various elements of the materials (text, audio, video, etc)
28 - 35	open ended questions (see Table 3.7) with space provided for response
36	17 aspects of teaching and planning with a request to mark those for which the materials gave some insight
37	open ended invitation to add any other comments

Items 1 to 27 and the list of aspects of teaching provided in item 36 are shown in full in Appendix C. Typical items included:

> The problem presented in this multimedia package was relevant to my future work as a teacher.

> The visual quality of the video presented on this multimedia package is very good.

Table 3.7 shows the open ended questions used in the questionnaire.

Table 3.7: Open ended questions on prototype evaluation

Item	Question
28.	What were your first impressions of the multimedia package materials?
29.	What are the weakest points or parts of the software? Please explain.
30.	Which was your favourite part or section of the software? Please explain.
31.	How might the multimedia package be improved?
32.	What do you think was the greatest benefit to you from using the multimedia package?
33.	What, if any, benefit to your professional development do you believe you gain through working with materials like this multimedia package?
34.	What specific aspects of teaching with technology did you learn about by working with this multimedia package?
35.	Do you think that other teachers would gain insights into teaching with technology by using this multimedia package?
37.	Please add any other comments you may have about the materials you have worked with.

The questionnaire was administered to students immediately after they had finished working with the prototype materials.

3.6 Beta evaluation

An account of the heuristic method used in the beta evaluation of the IMM-PBL materials has been published previously (Albion, 1999a). The material in this section is extracted from that paper with slight modifications.

Usability inspection is the generic name for evaluation methods that rely upon the considered judgement of inspectors. Various inspection techniques have been described, such as heuristic evaluation, pluralistic walk-through, cognitive walk-through (Nielsen & Mack, 1994), and graphical jog-through (Demetriadis, Karoulis, & Pombortsis, 1999).

Heuristic evaluation is among the easiest methods to learn and results in problem reports that appear to be better predictors of end-user problems (Mack & Nielsen, 1994). The method uses multiple evaluators who conduct independent inspections in which they compare interface elements with a list of recognised usability principles, the heuristics. An heuristic is a general guide for some activity, what might be described as a 'rule of thumb'. The heuristics compiled by Nielsen (1994) included such widely accepted principles of user interface design as "supports recognition rather than recall" and "prevents errors".

The reports of the multiple evaluators are considered together in order to maximise the chances of properly identifying any usability problems. Studies have found that the use of 3 to 5 evaluators is the reasonable minimum that will ensure identification of about 75% of usability problems in a project. The use of more evaluators will result in only marginal improvements in the rate of detection (Nielsen, 1994).

Table 3.8 shows the interface design heuristics as described by Nielsen (1994) and used in this study. Minor changes to the wording were made to facilitate understanding by evaluators from non-technical backgrounds.

Table 3.8: Interface design heuristics – after Nielsen (1994)

Heuristic	Description
Ensures visibility of system status	The software keeps the user informed about what is going on through appropriate and timely feedback.
Maximises match between the system and the real world	The software speaks the users' language rather than jargon. Information appears in a natural and logical order.
Maximises user control and freedom	Users are able to exit locations and undo mistakes.
Maximises consistency and matches standards	Users do not have to wonder whether different words, situations or actions mean the same thing. Common operating system standards are followed.
Prevents errors	The design provides guidance which reduces the risk of user errors.
Supports recognition rather than recall	Objects, actions and options are visible. The user does not have to rely on memory. Information is visible or easily accessed whenever appropriate.
Supports flexibility and efficiency of use	The software allows experienced users to use shortcuts and adjust settings to suit.
Uses aesthetic and minimalist design	The software provides an appealing overall design and does not display irrelevant or infrequently used information.
Helps users recognise, diagnose and recover from errors	Error messages are expressed in plain language, clearly indicate the problem and recommend a solution.
Provides help and documentation	The software provides appropriate online help and documentation which is easily accessed and related to the users' needs.

It is axiomatic that software of any type should meet basic standards for usability. In pursuit of this goal, usability inspection methods for user interface evaluation can be applied to educational software. However, Quinn (1996) proposed that usability inspection approaches might be adapted for the purpose of evaluating the educational design of software.

In Quinn's model the evaluators would include representatives from the target learner group, educational design experts and content experts for the relevant domain. The heuristics would comprise a compilation of elements of good educational design based upon tenets of relevant educational theories.

Quinn developed a draft list of eight heuristics based upon theories including cognitive apprenticeship, anchored instruction, problem-based learning and technology-mediated instruction. These were selected because, despite their differences in emphasis and sequencing, they are broadly constructivist and share characteristics such as engaging the learner in sequenced activities and guided reflection on learning.

Such an evaluation of the educational design of software would not replace usability inspection. However, since there is likely to be some overlap in the problems identified, Quinn suggested that the numbers of evaluators for each process could be kept low for a total of 6 to 8 evaluators. Quinn's original paper did not report on the results of any trials of the method. Nor do there appear to be any published reports of subsequent trials.

The instructional design implemented in the IMM-PBL package was relatively novel and there was a desire to validate the educational value of the design. Moreover, its constructivist orientation matched the theories on which Quinn (1996) had based his proposal for heuristic evaluation of educational design. Hence Quinn's method was selected for use. Table 3.9 shows the educational design heuristics as adapted from Quinn (1996).

Table 3.9: Educational design heuristics – after Quinn (1996)

Heuristic	Description
Clear goals and objectives	The software makes it clear to the learner what is to be accomplished and what will be gained from its use.
Context meaningful to domain and learner	The activities in the software are situated in practice and will interest and engage a learner.
Content clearly and multiply represented and multiply navigable	The message in the software is unambiguous. The software supports learner preferences for different access pathways. The learner is able to find relevant information while engaged in an activity.
Activities scaffolded	The software provides support for learner activities to allow working within existing competence while encountering meaningful chunks of knowledge.
Elicit learner understandings	The software requires learners to articulate their conceptual understandings as the basis for feedback.
Formative evaluation	The software provides learners with constructive feedback on their endeavours.
Performance should be 'criteria-referenced'	The software will produce clear and measurable outcomes that would support competency-based evaluation.

Heuristic	Description
Support for transference and acquiring 'self-learning' skills	The software supports transference of skills beyond the learning environment and will facilitate the learner becoming able to self-improve.
Support for collaborative learning	The software provides opportunities and support for learning through interaction with others through discussion or other collaborative activities.

Although Quinn referred to the inclusion of 'content experts' among the potential evaluators, his heuristics did not specifically address content issues. The nature of this package and its use of content to create context in the scenarios made it important to evaluate the authenticity of the included content in addition to the interface and educational design. Hence a third set of heuristics directed towards content was developed. Table 3.10 lists the content heuristics adopted for use in this study.

Table 3.10: Content heuristics

Heuristic	Description
Establishment of context	The photographs, documents and other materials related to the simulated schools create a sense of immersion in a simulated reality.
Relevance to professional practice	The problem scenarios and included tasks are realistic and relevant to the professional practice of teachers.
Representation of professional responses to issues	The sample solutions represent a realistic range of teacher responses to the issues and challenge users to consider alternative approaches.
Relevance of reference materials	The reference materials included in the package are relevant to the problem scenarios and are at a level appropriate to the users.
Presentation of video resources	The video clips of teacher interviews and class activities are relevant and readily accessible to the user.
Assistance is supportive rather than prescriptive	The contextual help supports the user in locating relevant resources and dealing with the scenarios without restricting the scope of individual responses.
Materials are engaging	The presentation style and content of the software encourages a user to continue working through the scenarios.
Presentation of resources	The software presents useful resources for teacher professional development in an interesting and accessible manner.
Overall effectiveness of materials	The materials are likely to be effective in increasing teachers' confidence and capacity for integrating information technology into teaching and learning.

The heuristics were presented to the evaluators on a form where each heuristic was accompanied by a rating scale (1 = poor to 5 = excellent, with an additional rating of NA for "Not Applicable") and space for comments. The heuristic evaluation method as described by Nielsen (1994) does not use such a rating scale although evaluators may be asked to rate the severity of problems they identify. In the present evaluation it was considered that the addition of a rating scale might lend itself to obtaining an overall assessment of the perceived quality of the materials. Evaluators were asked to rate the package on each characteristic and to add any relevant comments in the spaces provided. To ensure ample space for comments, the forms were printed on one side only of the paper and evaluators were encouraged to add additional pages as necessary.

Fifteen persons were invited to participate in the beta evaluation. The group of evaluators was chosen to include persons with expertise in user interface design, instructional or educational design and teaching. Two undergraduate students were included to provide reactions representative of the intended user group.

A beta version of the CD-ROM was supplied to evaluators for use on their own equipment. This approach provided for evaluation under conditions approximating those of intended use on a variety of computer systems with different browsers. It was also convenient for the evaluators who would otherwise have been required to commit a substantial period of time to work through the material in a test facility. However, this flexibility introduced some problems with providing support to the less technically adept evaluators in respect of the installation of ancillary software or dealing with minor problems which arose. It also increased the likelihood of delays in obtaining responses.

A copy of the instrument is included in Appendix D.

3.7 Evaluation trial

The original target environment for the IMM-PBL materials was a compulsory final year curriculum planning subject in the Bachelor of Education (Primary). Significant changes occurred in faculty personnel and the manner of teaching that subject during the development period of the IMM-PBL materials. Consequently that environment was no longer readily available for the evaluation trials.

Instead, a final year elective subject, *Information Technology for Teachers*, which had an anticipated enrolment of approximately 50 students was selected for the evaluation. Because of the close match between the content of the subject and the ICT related content of the IMM-PBL materials, it was possible to arrange for four weeks of the practical sessions of two hours each to be allocated to working with the IMM-PBL materials.

A pretest-posttest design was planned for the evaluation using the instruments listed in Table 3.11. Because, as described in section 3.1, the focus of the study was on the effects of IMM-PBL on pre-service teachers' self-efficacy beliefs for teaching with computers, the variable of central interest was the self-efficacy (SE) sub-scale of the MUTEBI. In addition, it was thought that both the form and content of the IMM-PBL materials might influence outcome expectancy (OE) as measured by the MUTEBI and the various sub-scales of the ACT and SCT. However, it was not anticipated that there would be significant impact on the other scales, PCI, Teacher Efficacy and Innovativeness. For this reason, and to reduce the load on respondents, the latter scales were not included in the posttest instrument.

Table 3.11: Instruments used in the evaluation trial

Instrument	Pretest	Posttest
ACT - Attitudes towards Computer Technologies	X	X
SCT - Self-efficacy for Computer Technologies	X	X
PCI - Pupil Control Ideology	X	
Teacher efficacy	X	
Innovativeness	X	
MUTEBI - Microcomputer Utilisation in Teaching Efficacy Beliefs Instrument	X	X
Open questions about teaching with computers	X	X
User evaluation questionnaire (experimental group only)		X
Participant journals (experimental group only)		X
Interviews (experimental group only)		X

The students in the target subject group (n = 45) represented fewer than half of the final year population, thus allowing the use of a second group of final year students (n = 50) as a control. The pretest instruments were administered in a mass lecture for a compulsory subject being taken by final year students. The author spoke to the group about the study and explained how to complete the questionnaire. Time was allowed during the lecture for completion of the forms which were collected immediately afterwards.

All lectures and computer laboratory sessions in the target subject were conducted by another member of the faculty who was unfamiliar with the IMM-PBL materials. This arrangement reduced the risk of confounding which would have been present had the author been directly involved in working with the experimental group in class. During the second week of the semester the author visited the lecture session at the invitation of the lecturer to explain the nature of the trials and to explain the use of the journals which were to be completed at each use of the materials. A brief demonstration of the software was conducted and students were issued with a CD-ROM containing the IMM-PBL materials and a headset for use in the laboratory. They were informed that both were theirs to keep. Laboratory sessions commenced the following day.

The practical classes were scheduled for a computer laboratory equipped with Pentium computers running Windows NT. Because the ILS group had produced multimedia materials similar in system requirements to the IMM-PBL materials for use in other university subjects, they had previously arranged for laboratory systems to be appropriately configured. In order to confirm the operation of the software in the laboratory, about five weeks before the evaluation period, the author conferred with the laboratory manager and arranged for the IMM-PBL material to be tested on a computer configured to the standard laboratory specification. The software operated without errors on the test system.

Despite the assurances of the laboratory staff and the checks they conducted, the first sessions in the laboratory did not go smoothly. Although all computers in the laboratory were of the same make and model and had software installed from the same image stored on a server there were minor differences in configurations which interfered with the operation of the IMM-PBL materials on about ten of the twenty computers in the laboratory.

Technical staff worked to resolve the problem but it was the third week of the planned evaluation before all computers were operating as they should.

An additional problem resulted from the security system on the computers preventing the storage of cookies beyond a single session. This prevented students from being able to exit the software and resume later at the same point. In the second week and beyond, students were supplied with a list of URLs that enabled them, once past the IMM-PBL login, to go direct to the page where they had been working most recently and continue from there.

Posttest instruments were distributed to the experimental group during the week following the last laboratory period in which they worked with the IMM-PBL materials. Because there was insufficient time for students to complete the forms during class they were invited to return them later to the department office.

Of the students who completed the pretest instruments, there were 100 who were enrolled in the same courses as the experimental group and were not studying the target subject. A control group was constructed by randomly selecting fifty of these students. On the same day as the posttest was distributed to the experimental group, the questionnaires were mailed to the control group with a covering letter explaining the nature of the study and a reply paid envelope.

To maximise the response rate, one week after the first distributions, additional copies of the instruments and reply paid envelopes were mailed to all students from both the experimental and control groups who had not already returned their responses.

In order to obtain a broader understanding of the way in which users interacted with and responded to the IMM-PBL materials, there was a need to gather qualitative data as well as the quantitative data generated by the various Likert scale instruments. These data were collected from several sources including open ended questions within the pretest and posttest batteries, open ended questions in the user evaluation questionnaire, participant journals and interviews with a small group of participants in the evaluation.

Samples of the instruments as administered are presented in the Appendices. Appendix E presents the pretest form of the multi-instrument questionnaire. The posttest form differed only in that it omitted most of the demographic items. Appendices F and G represent the user evaluation questionnaire and participant journals respectively.

3.7.1 ACT and SCT

These instruments were used in the same format as had been used at the time of the prototype trial.

3.7.2 MUTEBI, PCI, teacher efficacy and innovativeness

The items used in these instruments were the same as those used at the time of the prototype trials. However, following advice obtained from an experienced researcher with specialist statistical training, all Likert scales were compressed to four point scales ranging from strongly disagree (1) to strongly agree (4). The entire instrument, including the ACT and SCT scales was then presented in a consistent fashion.

3.7.3 Open questions about teaching with computers

Using the categories developed from analysis of the consultant interviews as a basis, six open ended questions were developed for inclusion with the pretest and posttest instruments. The intent of these questions was to probe users' knowledge of topics treated in the teacher interviews before and after use of the IMM-PBL materials. The questions are listed in Table 3.12.

Table 3.12: Open questions as used in the evaluation trials

1	What do you think would be the most important reason(s) for using computers in your future work as a teacher?
2	What do you think would be the best way(s) for you to continue to develop your knowledge and skills for teaching with computers during your teaching career?
3	What do you think would be the most important thing(s) to consider when you are planning to use computers in your teaching?
4	What do you think would be the most significant effect(s) of using computers in your teaching?
5	What do you think would be the greatest challenge(s) you would face in using computers in your teaching?
6	What do you think would be the most important thing(s) to understand about the Internet if you were using it in your teaching?

The open questions were administered in the same questionnaire as the ACT, SCT, MUTEBI and other scales and were presented with space provided for a response directly following each question.

Responses were coded by the author according to the categories determined by analysis of the consultant interviews.

3.7.4 User evaluation questionnaire

The user evaluation questionnaire from the prototype trial was used with some minor modifications. Ten of the twenty items in the first group of Likert scale items were modified. In three cases, the changes were the addition of an 's' to refer to 'problems' rather than 'problem' in recognition of the completed IMM-PBL comprising four problem scenarios as compared to the one in the prototype. Other changes involved changing some items from negative to positive phrasing and completely replacing one item. The complete instrument is included in Appendix F.

An additional open ended question was included as follows:

> How would you describe the multimedia materials to a colleague who had not seen them?

3.7.5 Participant journals

Data collected using the instruments already described were expected to provide a sufficient basis for examining the effects of the IMM-PBL materials in use. However, the manner in which students interacted with the materials was expected to influence their reaction to the materials and the ultimate effects on measures such as the MUTEBI.

Direct observation of students working with the materials over the period of the trial was impracticable because of the number of students involved. Moreover, observation by the author might have resulted in students' use of the materials being influenced through suggestions offered in response to students' questions. Hence, journals were proposed as a means of collecting data about students' patterns of use of and immediate responses to the IMM-PBL materials.

All participants in the evaluation were provided with a prepared journal page (see Appendix G) for each laboratory session. The page included a brief statement describing the intended use of the journal data and advising students that any reporting of data would be anonymous. The page included spaces for recording name, date and length of time spent working with the materials in the relevant session. The remainder of the page comprised the questions listed in Table 3.13 with space provided for recording a response beneath each question. The instructions advised students that if there was insufficient space for their comments they could use the back of the page or append additional pages. They were provided with one journal page for each of the scheduled sessions and advised that additional pages would be provided on request.

Table 3.13: Questions used in the participant journal

What specific parts (resources, tasks, etc) of the CD-ROM materials did you work with in this session?
What did you do during this session? (Briefly describe what you did during the session)
What were the most important things you learned during this session?
What questions or issues that you identified as important to you emerged from this session?
What was your personal reaction to the activities you completed in this session?

As an encouragement to students to maintain the journals, the staff member responsible for the class advised students that the journals could be included as part of an assessment portfolio to be submitted for the subject within which the IMM-PBL materials were used. Students were asked to submit their journals with their responses to the posttest questionnaires.

Submitted journals were copied for analysis and the originals were returned to the students for use in the assessment portfolio. Data from the journals was not subjected to formal analysis but were used to increase understanding of the manner in which students approached their use of the IMM-PBL materials.

3.7.6 Participant interviews

Interviews with a small sample of students were proposed as a further source of data about students' experience with and response to the IMM-PBL materials. In the week following the distribution of the posttest questionnaires, the author visited the laboratory sessions and invited students to participate in short interviews about the experience of working with the materials. Students were advised that any reporting of interview data would be anonymous and that their responses would not affect their grades. They were also advised that, in addition to responding to the interview questions, they would have opportunity to offer any comments or reflections they might have.

Four students (one male and three female) agreed to participate. The interviews were based around the schedule of questions listed in Table 3.14. If students had difficulty with a question it was rephrased. Where a response seemed incomplete, supplementary questions were asked to expand the response.

Table 3.14: Schedule of questions for participant interviews

About how much time altogether did you spend working with the materials?
Please tell me about the strongest memory you have of using the materials.
Please think of any one of the four problems and describe what happened in that problem.
Tell me about something that you learned from the materials.
When you think about what happened as you worked through the problems, how important are the details of the stories - people, places, and so on?
To what extent were you able to identify with the events in the problems?
How realistic and relevant to the work of teachers do you think the problems presented in the materials were? Can you give examples?
How important do you think it was to have your name appear in elements such as the letters and email messages? Please explain why.
What other comments would you like to make about the materials?

The interviews were recorded on audio tape and transcribed by the author. The transcripts were not subjected to formal analysis but were used in a similar manner to the journal entries to illuminate students' experiences with and responses to the IMM-PBL materials.

Chapter 4: IMM-PBL materials design & development

As noted in Chapter 3, before any effects of IMM-PBL on pre-service teachers' self-efficacy for teaching with computers could be investigated, it was necessary to design and develop an IMM-PBL package relevant to teaching with computers. This chapter describes the processes of design and development.

Interactive multimedia is a complex product. Its design and development is typically undertaken by a team of people in order to assemble the necessary range of skills and the process involves several stages including testing and progressive refinement. The overall process envisaged for this project may be viewed in terms of the following steps:

1 Conceptualise the intended product including a description of the operation of the materials and an indication of the educational theories and approaches on which it would be based.

2 Identify and develop the content to be included in the materials.

3 Select an appropriate software environment for the development.

4 Develop a prototype that includes key features of the intended product and trial it with a group that is representative of the anticipated users.

5 Using the results of the trials, refine the design of the materials.

6 Develop and test a beta version of the software to eliminate serious errors.

7 Based on the results of beta testing, revise the materials to create a completed version for testing under conditions of actual use in a class.

4.1 Funding and personnel

The author had previously conceptualised multimedia materials designed to prepare pre-service teachers for teaching with computers (Albion, 1995). At that time the proposed design was based on the creation of hypermedia cases using cognitive flexibility theory (Jacobson, Maouri, Mishra, & Kolar, 1995; Jacobson & Spiro, 1995; Nelson & Smith, 1994). Development would have been undertaken using the resources provided to support teaching in the relevant subjects.

In November 1995 the Commonwealth of Australia Department of Employment Education Training and Youth Affairs (DEETYA) invited submissions for funding of special projects under its National Priority (Reserve) Fund Teacher Education Initiative. The focus of funded projects was to be the enhancement of the "information and communications technology literacies of beginning teachers".

Discussions with a colleague with similar interests, Dr Ian Gibson, resulted in a joint submission (Gibson & Albion, 1996) which incorporated elements based upon ideas contributed by both of the project initiators. A decision was made to locate the use of the multimedia materials by students within a required subject dealing with curriculum planning. That subject was studied by all pre-service primary teachers in their final semester of study and had been taught in previous years using a problem-based learning approach (Gibson & Gibson, 1995) with a focus on preparing to teach in multi-age classrooms in predominantly rural locations. Hence it was decided to investigate the implementation of a PBL design with a focus on planning for teaching using ICTs. The application for funding was based on this model.

The submission was successful in obtaining a grant of $60 000 that became available early in 1997. Funds from that grant were used to support development of the materials as described in this study.

When funding was obtained for the IMM-PBL project, it became possible to employ research assistants to assist in collection and preparation of content from a variety of sources, including a small group of cooperating teachers who are referred to in the materials as *consultants*. Arrangements were made to obtain technical services including graphic design, photography, video and audio production, computer programming and CD-ROM mastering through the Interactive Learning Services (ILS) section within the Distance Education Centre (DEC) of the University of Southern Queensland (USQ). A project manager was assigned by DEC to liase with the project directors, namely Dr Ian Gibson and the author.

In most respects the development team functioned as anticipated. Difficulties encountered in the programming beyond the stage of prototype development resulted in the author assuming responsibility for project management and materials development from August 1998, six months beyond the scheduled completion date.

By that time, although the project was far from complete, much had been already accomplished. The original concept (Gibson & Albion, 1996) had been enhanced by the development of a design model for IMM-PBL (Albion & Gibson, 1998a). A development process had been described (Gibson & Albion, 1997) and applied to the preparation of a prototype. A paper describing the project (Albion & Gibson, 1998b) had received an award at an international conference. The outlines of all four scenarios had been developed and most of the content had been prepared.

The drawing together of these threads and their expression in the final product which emerged as the *Integrating Information Technology into Teaching* CD-ROM (Gibson & Albion, 1999) was predominantly the work of the author. The educational design emerged through collaboration with the project co-director and the completed package includes images, audio, video, text and some embedded Shockwave elements prepared by members of the team described above. The conversion of text materials for display in the final version, the creation of some graphics, the arrangement of elements on the screen, and the programming that controls their operation is the work of the author.

In the following sections, significant features of the design and development process are described. It may be assumed that, except where it is otherwise indicated, all of the materials development work described beyond the point of prototype development has been undertaken by the author.

4.2 Software development environment

Two early decisions about the IMM-PBL materials imposed significant requirements that affected the selection of a development environment. The first was that the materials should be capable of being used on both Microsoft Windows and Apple Macintosh computers. This cross-platform requirement eliminated some potential development systems such as HyperCard and SuperCard (Macintosh only) and ToolBook (Windows only). The second requirement was that the materials would include substantial amounts of digitised video in order to enhance the users' appreciation of the context of any examples.

At the outset, serious consideration was given to implementing the materials as web pages (HTML) and using a web browser such as Netscape Navigator or Microsoft Internet Explorer for delivery. This solution would have ensured cross-platform access and could have supported the use of video and other media elements through the use of plug-ins such as QuickTime and Shockwave. It would also have permitted delivery from a web server on either a local network or across the Internet. Because it was known that the materials would include over an hour of digitised video (at least 500 Megabytes) it was thought that delivery from a web server was unlikely to be feasible within the anticipated life of the product.

A web version could have been delivered using CD-ROM and the programming team had successfully completed projects using that model. However, advice from the programming team indicated that the browser security model might prevent storage and retrieval of certain kinds of data on a user's hard drive. That, in turn, might prevent a user from being able to reliably exit the materials and resume at the same point at a later time. This feature was critical in a product that would restrict users' ability to move randomly among locations as described below. Based on these considerations, the web browser alternative was rejected.

At the time when the initial discussions about development environments were held, the programming group had begun to undertake development using Macromedia Director. Moreover, they had recently engaged a new programmer specifically to work in that environment. Because Director was widely used for cross-platform multimedia development and was well suited to integrating video, animation and other media within a single multimedia product, it was selected as the development environment and work on the prototype commenced.

Previous work using PBL had presented the problems as written scenarios including contextual information that assisted students in understanding the nature of the problem environment (Gibson & Gibson, 1995). Based on this experience, the IMM-PBL materials were conceived as a set of four problems each presented as a series of tasks with contextual information. Each of these problems and its associated material was referred to as a *scenario*. For simplicity, the prototype was based on a single scenario.

Between September 1997 when the prototype was tested and March 1998, when the completed materials were scheduled to be evaluated in trials with students, there was little apparent progress in the program development. Few of the changes that had been agreed in the design revision following the trials had been implemented and there were persistent bugs. Because it was possible that the difficulties were associated with failure to communicate information about the intentions of the designers to the programmers, in March 1998 the author undertook to develop a working demonstration of the first problem scenario. The intention was to demonstrate the desired functionality in a way that would make the designers' intentions clearer than might be achieved through discussion or written instructions.

Despite its unsuitability as a final development platform because of cross-platform requirements, HyperCard was selected for the demonstration because of the author's familiarity with it. It had the additional advantage of a programming language similar to that in Macromedia Director, which made it likely that functionality achievable in HyperCard should also be achievable in Director. Using graphics captured from the Director prototype and other resources prepared for the prototype, a working demonstration was completed within three weeks and was used to demonstrate the desired functionality and flow of logic to the programming team. Because this version was significantly more functional than the prototype at that time, it was used by the project directors in a conference presentation (Albion & Gibson, 1998a) and by the author for presentations to colleagues at universities in the USA and UK during May and June 1998. Positive reactions to the presentations confirmed the value of the IMM-PBL concept. Ideas for refinement and extension of the materials were also suggested.

In July 1998 the author met with the programming group to discuss alternatives for completing the project. The advice of the programmers was to cease development of the entire project in Director and, instead, develop in web format. Institutional priorities had shifted towards developing multimedia materials for viewing in web browsers either on the Internet or on CD-ROM and the reservations the programmers had originally expressed about the suitability of a web environment no longer applied. The project objectives could now be achieved in web format and some elements already created in Director could be embedded in the web version using Shockwave. Given that development of the Director version had been effectively stalled for six months and that the demonstration version prepared in HyperCard was not a suitable alternative for the final version, a decision was made to switch to development for a web environment.

For reasons of efficiency in production, the programming team favoured using a web format similar to that being used for other projects on which they were working. They had developed a system by which word processing documents prepared in Microsoft Word were formatted using a specialised mark-up language (ILS-ML) and converted to a web site by a customised program (Evans, 1998).

Because, in the opinion of the project directors, including the author, the proposed format was not consistent with the intended design of the IMM-PBL materials, it was agreed that the author would undertake the conversion to web format. The programming team would continue development of two embedded interactive modules to be delivered using Shockwave, provide access to the ILS-ML conversion software and limited technical support, and prepare the final master of the proposed CD-ROM for replication.

The remainder of the development process was completed using a variety of software tools to prepare the web pages and associated content and to write and debug the JavaScript code that controlled the logical flow of the materials. Significant aspects of the development process are described below.

4.3 Overview of the development process

Different approaches may be taken to software development. One approach requires development of a detailed analysis and specification before any coding is undertaken to create a product according to the specification. Alternatively, a prototype may be developed from a partial specification and refined on the basis of user response (Senn, 1989). For this project the latter approach was adopted because it offered opportunities for testing and refining aspects of the design before committing to the final product. Given the novelty of the IMM-PBL approach it was thought better not to freeze the design too early in the development cycle.

Thus the design of the materials evolved through a succession of cycles in which ideas were conceived, tested through discussion or later through partial implementation, evaluated and revised. Techniques for representing and implementing ideas also evolved along with more systematic approaches to the design process. Most processes were worked through with the first of the anticipated four problem scenarios and the process of designing the second and subsequent scenarios benefited from the establishment of routines and conventions of representation.

The following excerpt from a paper prepared around the time of the prototype trial in September 1997 summarises the development process as it was proceeding at that time:

> (Figure 4.1) represents the general flow of the development process for this project together with the personnel involved in various phases. Periods in which particular elements of the team were centrally involved are represented by solid lines while dashed lines represent periods of more peripheral involvement. For example, while the programmers were most centrally involved in the creation of the program code they were consulted during storyboarding conferences and in relation to the file formats required for various resources.

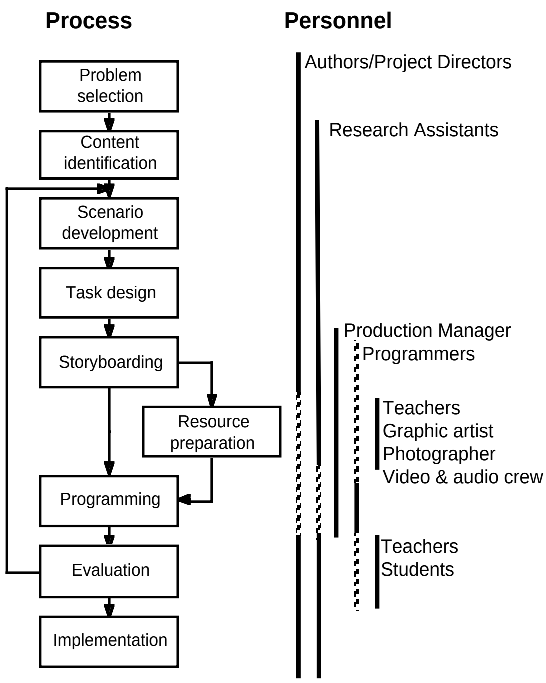

Figure 4.1: Overview of the development process

> Although the process is represented in (Figure 4.1) as linear, there were significant departures from a strict chronological sequence. For example, the video crew had to be booked well in advance and recording was planned on the basis of broad content identification and completed several months before the scenarios were developed and storyboards finalised. Selection of video segments from the several hours of recorded material was also undertaken at that time. However, the video was not digitised until programming had commenced and the advice of the programmers on the appropriate file formats had been obtained. (Gibson & Albion, 1997)

The process and allocation of roles as shown in Figure 4.1 corresponds closely to the original project schedule as shown in Table 3.2. Under this plan, the project co-directors were responsible for educational design and general oversight of the design and development of the project. All other aspects of the IMM-PBL materials development, including creation of content and computer programming, were undertaken by personnel employed using the grant funds.

Progress on design and development of the IMM-PBL materials fairly closely matched the schedule outlined in Table 3.2 up to the point of testing the prototype and refining the materials design. Beyond that time, the development process became much more protracted than expected for several reasons. The other project director accepted a position elsewhere at the end of 1997, leaving the author to assume responsibility for completing the project with only limited collaboration by email. Other personnel had been committed to the project on the original schedule and became unavailable due to their other obligations. The author's other workload, including travel planned according to the original project schedule, imposed further limitations.

4.4 Conceptualising scenario development and structure

Overall, the intention of the designers was that users would "encounter a series of distinct and increasingly intricate problems representative of the typical experience of a newcomer to teaching with technology developing confidence and increasingly more effective teaching approaches with computers" (Gibson & Albion, 1997, p. 161). It was thought that a set of four problem scenarios was achievable and would be sufficient to test the value of the IMM-PBL design model.

Broad planning of the scenarios was undertaken by the project co-directors. Once the general pattern was established the details were worked out in conjunction with the research assistants who then assumed responsibility for assembling the required content.

Early in the development process the anticipated composition of the four problem scenarios was as follows:

1. A stand-alone computer is to be provided for a classroom and the teacher must consider the physical arrangement of the room, classroom management issues and the potential impact on teaching style.
2. Issues to be introduced would include curriculum planning for integration of computers for a single lesson and a unit of work.
3. Issues to be introduced would include application of computers to teaching specific subject areas in a unit of work and placement of equipment in laboratories or classrooms.
4. This scenario was expected to deal with team teaching, use of the Internet for teaching, and broader school issues including relevant policy.

In order to provide scaffolding for pre-service teachers using the materials, each problem was to be decomposed into a series of tasks (Savery & Duffy, 1995). All four scenarios were to be situated in the context of a teacher seeking employment and the first task in each was preparation of a response to the appropriate selection criterion as found in the advertisement for the position. Much of the initial design effort was directed towards conceptualising realistic contexts for each scenario and devising tasks which had plausible motivation in the context of the particular scenario while addressing the desired content.

Figure 4.2 (Albion & Gibson, 1998a) provides a conceptual overview of the process of developing a problem scenario. A textual elaboration of this figure appears below:

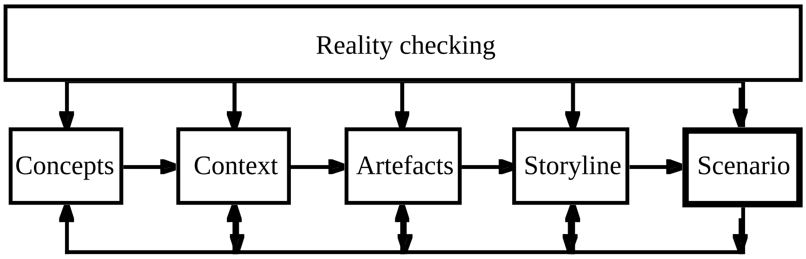

Figure 4.2: IMM-PBL scenario development

> Development begins with identification of key concepts from the content domain (Savery & Duffy, 1995) and a typical context in which the concepts might be used. A description of the context including aspects of the environment and the problem is developed. The problem is divided into a series of sub-problems to facilitate scaffolding by considering the types of artefacts, typically documents of various kinds, which might be produced in association with a stepwise solution to the problem situation. Finally, the scenario is completed by devising a storyline which describes the progress of the problem solver from initial encounter with the problem to final resolution and provides the motivation for the user. At each stage, effort is devoted to applying reality checks to ensure that the overall scenario, and each element of it, is plausible, and flows naturally according to user choice. The process tends to be iterative rather than linear and, as indicated in the lower portion of the figure, there is a feedback loop through which evaluations at each stage can influence subsequent revisions.(Albion & Gibson, 1998a)

Figure 4.3 (Albion & Gibson, 1998a) illustrates the conceptual structure of a typical problem scenario:

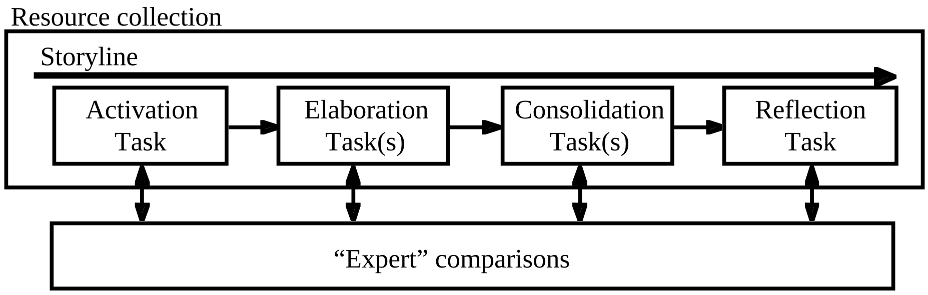

Figure 4.3: IMM-PBL scenario structure

> In order to assist the learner through metacognitive scaffolding, the problem scenario is presented as a series of tasks embedded in a storyline related to a professional context. Each task results in preparation of some artefact relevant to the problem. The Activation Task is intended to situate the learner in the problem context and to begin the process of activating relevant prior knowledge. Elaboration Tasks provide opportunity for recall and

> reconfiguration of prior knowledge relevant to the specific problem and exploration of additional, context specific knowledge and 'experience' gained during problem solution. Consolidation Tasks emphasise relevant knowledge transfer, analysis, integration, synthesis and evaluation of selected, context specific knowledge and problem based 'experience'. Finally, the reflection task is designed to encourage learners to further integrate knowledge, 'experience' and artefacts gathered through the problem solving process into their cognitive structures as though products of real experience.
>
> After each task, users are able to compare their artefact with examples from a panel of experts. These interactions with experienced professionals replace the interactions with peers (De Grave et al., 1996) or with a facilitator (Savery & Duffy, 1995). Except when the storyline requires otherwise, users have access to a collection of resources relevant to the concepts encapsulated in the problems. Because PBL is intended to increase the capacity of learners to solve real problems (Boud, 1985) and because identifying critical elements may be counter-productive (Savery & Duffy, 1995), the selection of resources for inclusion in the package is gauged to require judgement in selection from what is provided and initiative in employing material from alternative sources. (Albion & Gibson, 1998a)

For the purpose of illustrating the processes of scenario development and the resultant structure, the development of the first scenario will be described here in some detail. Similar processes were applied to each of the remaining scenarios.

Concepts identified for inclusion in the first scenario centred on classroom planning and management issues associated with the integration of a single computer into a classroom. Associated issues included the physical location of resources such as a computer in a classroom, planning for individual, small group and whole class work with a computer, and behaviour management in a classroom environment modified by the presence of a computer.

The assumed context was a small rural school with multi-age classes. The particular class to which the user of the materials would be assigned on a temporary appointment was about to be equipped with a new computer.

Artefacts identified as appropriate to this scenario included a response to a selection criterion focused on organising a classroom to optimise learning outcomes but not necessarily by using a computer, a diagram showing plans for arrangement of furniture and equipment in a classroom, brief notes on planning for classroom computer use to be discussed at a staff meeting and a summary of similar notes prepared by other members of staff.

Around these artefacts was built a simple storyline that began with the user applying for and being offered the position. With the offer of employment would come a suggestion from the principal of a side trip to visit a computer-using teacher and engage in a simulated interview (using video of one of the teacher interviews). On arrival at the school there would be an entry interview and tour with the principal culminating in an opportunity to visit (via video) with another teacher. Once in the classroom a plan of the room as adapted to accommodate the new computer would be prepared and submitted to the principal. A memorandum from the principal would refer to the notes to be prepared for the staff meeting and a telephone call would provide a reminder when the meeting was to begin. After the meeting a summary would be prepared for the principal and before departing from the school the principal would call to say "well done".

The tasks within the scenario corresponded to the artefacts identified above. In terms of the scenario structure as shown in Figure 4.3, writing to the selection criterion provided the activation task. Planning the classroom layout and preparing for the staff meeting provided for elaboration and consolidation. The preparation of a summary was intended to provide additional consolidation and opportunity for reflection.

4.5 Representing the IMM-PBL design

As the design of a scenario emerged according to the processes described in the previous section, it was necessary to maintain records of the design. Initially these records were used as working documents within the design team. As the design crystallised, documents were created to assist the research assistants in the collection and preparation of content and to provide the programmers and other members of the wider team with specifications from which to prepare the IMM-PBL materials.

The first attempt to document a pathway through a scenario was a *pre-prototype* that the author created in HyperCard. This served to demonstrate the concepts, which had been developed jointly by the project co-directors, to other members of the project team. Figure 4.4 shows the opening screen, a teacher's desk top.

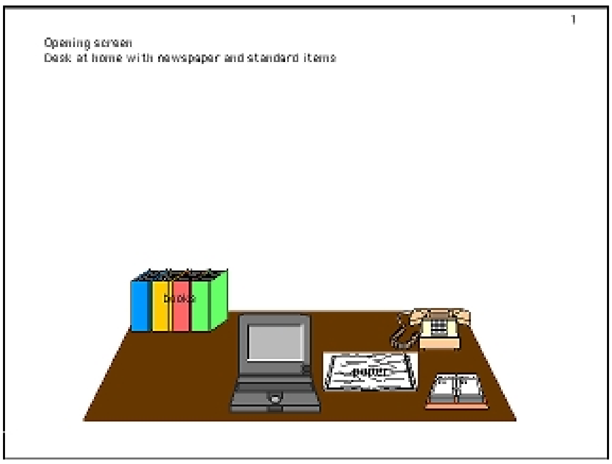

Figure 4.4: Opening screen of the pre-prototype

The pre-prototype included no content but served to clarify some aspects of the interface design and anticipated flow of action through the materials. Figure 4.5 represents the first few screens of the pre-prototype as they appeared when printed. Absence of graphics from the printed version is an artefact resulting from the use of imported colour images in HyperCard and the lack of clarity in the text results from the process of capturing and reducing an on-screen image.

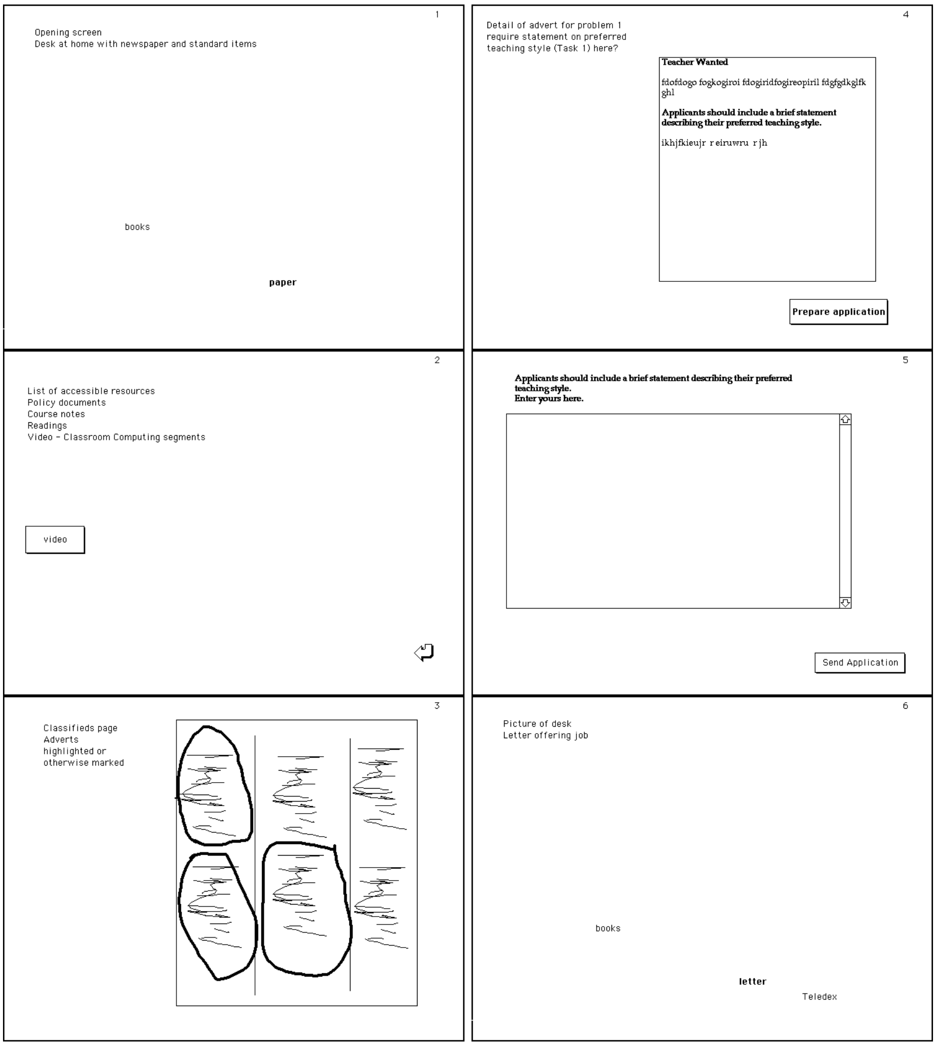

Figure 4.5: Printed representation of the pre-prototype

In keeping with the project directors' desire to provide the user with an *authentic* experience of the problem scenarios, the pre-prototype was designed to facilitate forward movement through the materials and to limit backtracking by providing no obvious backward links on the majority of screens. Although this represented a significant departure from the hypermedia paradigm frequently associated with constructivist IMM (Lawless & Brown, 1997; Spiro et al., 1991b), it was consistent with the use of narrative form in multimedia (Laurillard, 1998) and the guidelines for IMM-PBL derived in Chapter 2.

The screens in the pre-prototype did not always form a linear sequence. At certain points they provided for branching to alternative locations and return to the main sequence. For example, in screen 1 of Figure 4.5 "books" links to the resource area represented by screen 2. To advance from screen 2 through the scenario it would be necessary to return to screen 1 and use the "paper" link to move to screen 3.

A meeting of the project team reviewed the pre-prototype in operation and the printed screen images. The structure and flow specified in the pre-prototype represented only the first few stages of the first scenario but were sufficient to provide a basis from which to begin detailed planning of the scenarios and to inform discussions about selection of a development environment.

The scenario planning process typically took the form of "brainstorming" sessions involving the project directors and, on occasion, a research assistant. Ideas were recorded and diagrammed on a whiteboard as they were generated. The first pass through planning a scenario typically resulted in a general description of the issues on which it would focus, the materials which might be needed and the work that would be required of users. The results of the initial sessions were recorded in diagrammatic form and retained on the whiteboard for a review, which usually occurred within a day or two of the ideas being generated.

Figure 4.6 represents an early version of a storyboard prepared by the research assistants to record the planning for the first scenario. As may be discerned by inspecting the diagram, a rudimentary storyline had been developed to encompass reading of the advertisement, receiving the letter of appointment, arriving at the school, planning the classroom layout, preparing for and attending the staff meeting and completing the summary. The optional visit to a teacher in another school is indicated as an alternative path and various elements of content such as school profile, development plan and so on had been identified.

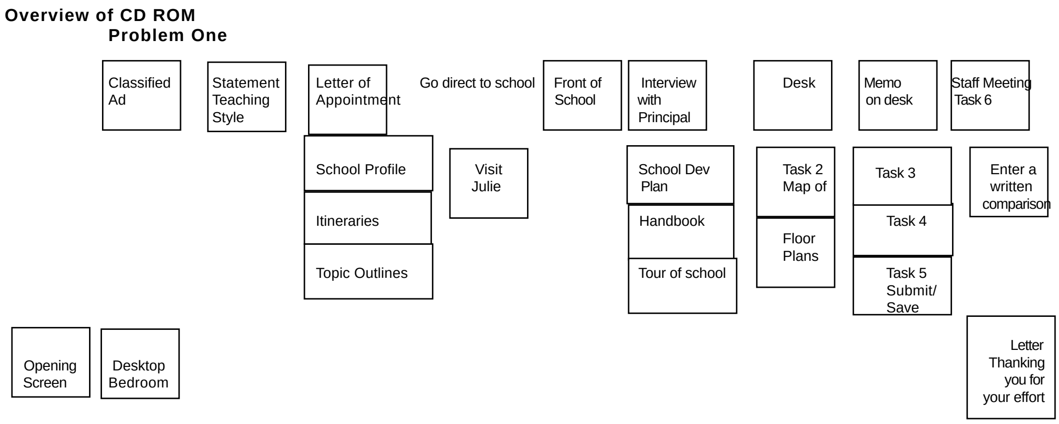

Figure 4.6: An early "storyboard" for the first scenario

Once the basic outline of a scenario had been developed, a process of elaboration and refinement ensued. The storyline was reviewed and reworked to ensure that it was plausible and could provide motivation for the proposed tasks. The tasks and the stimulus materials were also described in greater detail and additional documentation was prepared by the research assistants to guide the process of content preparation and the programming. Figure 4.7 is an example of a representation prepared by the research assistants at a later stage of planning for the first scenario. The increased level of detail is apparent.

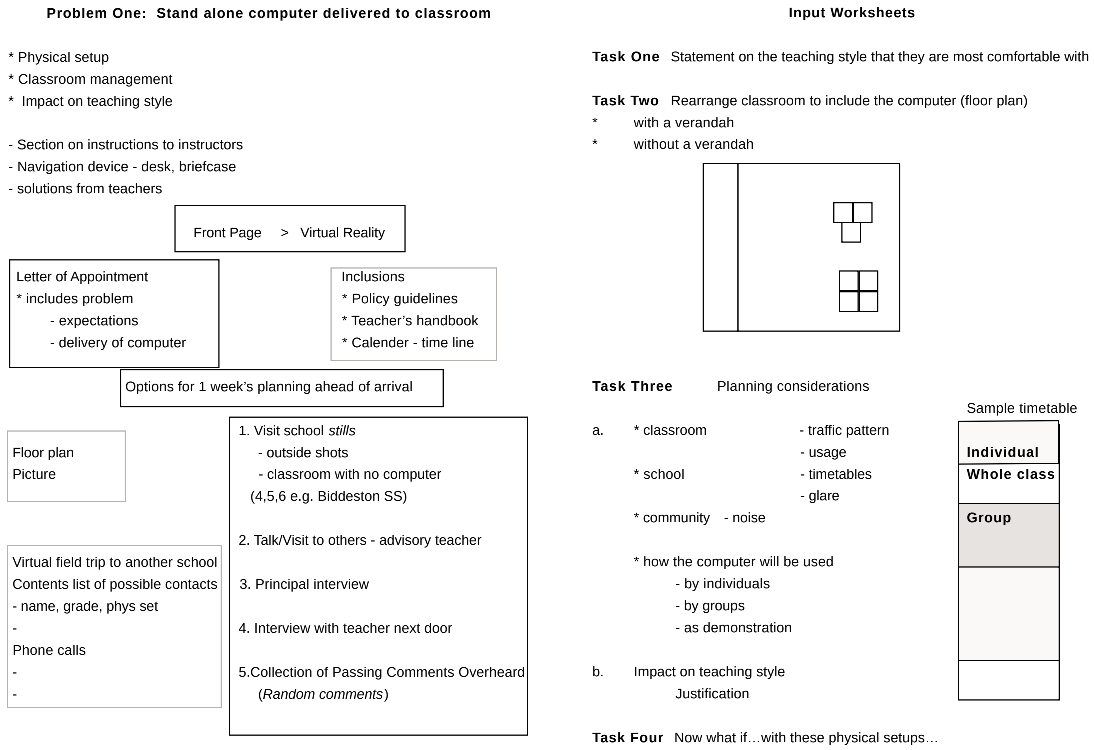

Figure 4.7: An intermediate planning stage for the first scenario

Once the scenario had been agreed by the project directors and was documented as shown in Figure 4.7, the research assistants proceeded to identify the specific content that would be required for that scenario. The various categories of content required for the IMM-PBL materials and their handling are described in section 4.6 below. As content elements became available they were converted, if necessary, to the appropriate file formats and transferred to the programming group for incorporation into the materials development process.

The IMM-PBL materials required the creation or collection and management of hundreds of individual elements including photographs, graphics, text, audio and video. Tracking the progress of each element represented a substantial management task. Figure 4.8 represents a portion of an assets register used by the research assistants to track content elements required for the project.

Asset Register Problem Two

Screen	File name	Descriptive name	Status	Location	Contact
3	Nelclass	Classified ad for Nelson Camp Primary	Final	DEC JM	
3a	Nelappl	Application cover letter	Final	DEC JM	
3b	Neltask1	Task 1 descriptor	Final	DEC JM	
3c	AUDIO	Audio: Compare to teacher responses?		Audio	Colin Webber
3d	NelKen1	Teacher sample from Ken	Final	S. Ed HK	

Figure 4.8: Portion of the assets register for scenario two

The effectiveness of these methods of documentation was demonstrated by their use in developing the prototype. Following the trials of the prototype with students, there was a thorough review of the prototype conducted in a series of meetings of the project directors, project manager, research assistants and programmers. Each screen in the prototype was reviewed and changes specified using a format developed by the project manager and shown in Figure 4.9. The collection of forms produced in this process provided a clear and consistent specification for the revision of the prototype.

Date: ……… Screen Design / Evaluation Screen Number: … Screen Name: ………

Description:

Comments:

Help:

	Asset #	Content / Appearance	Function
Graphics:			
Text:			
Video:			
Audio:			
Animation:			

Figure 4.9: Screen specification form used in the prototype review

When the revision of the prototype did not produce the anticipated results, the review forms were used, together with the previous documentation, to guide the development of the demonstration version in HyperCard. That process further clarified the logical flow of the scenarios and provided an alternative form of documentation.

By July 1998, when the author assumed responsibility for implementing the design, which had been developed jointly by the co-directors, the structure and flow of the first scenario was well defined. There were consistent patterns emerging, which could be applied to the further development of the remaining scenarios. Figure 4.10 shows the flowchart prepared by the author to clarify the structure and flow of the first scenario prior to commencing development of the web version of the IMM-PBL materials.

The flowchart has been designed to visualise the interrupted narrative structure (Bearman, 1997; Laurillard, 1998; Plowman, 1996; Sims, 1998) around which the scenario is built. Boxes shown in bold represent points at which the user pauses to interact. These locations frequently present tasks for which the user will access resources including those included in the materials. For simplicity in programming, the progress of a user through the materials was to be tracked by reference to these key locations. The categorisation of resources as *static* or *contingent* is described in 4.6 below.

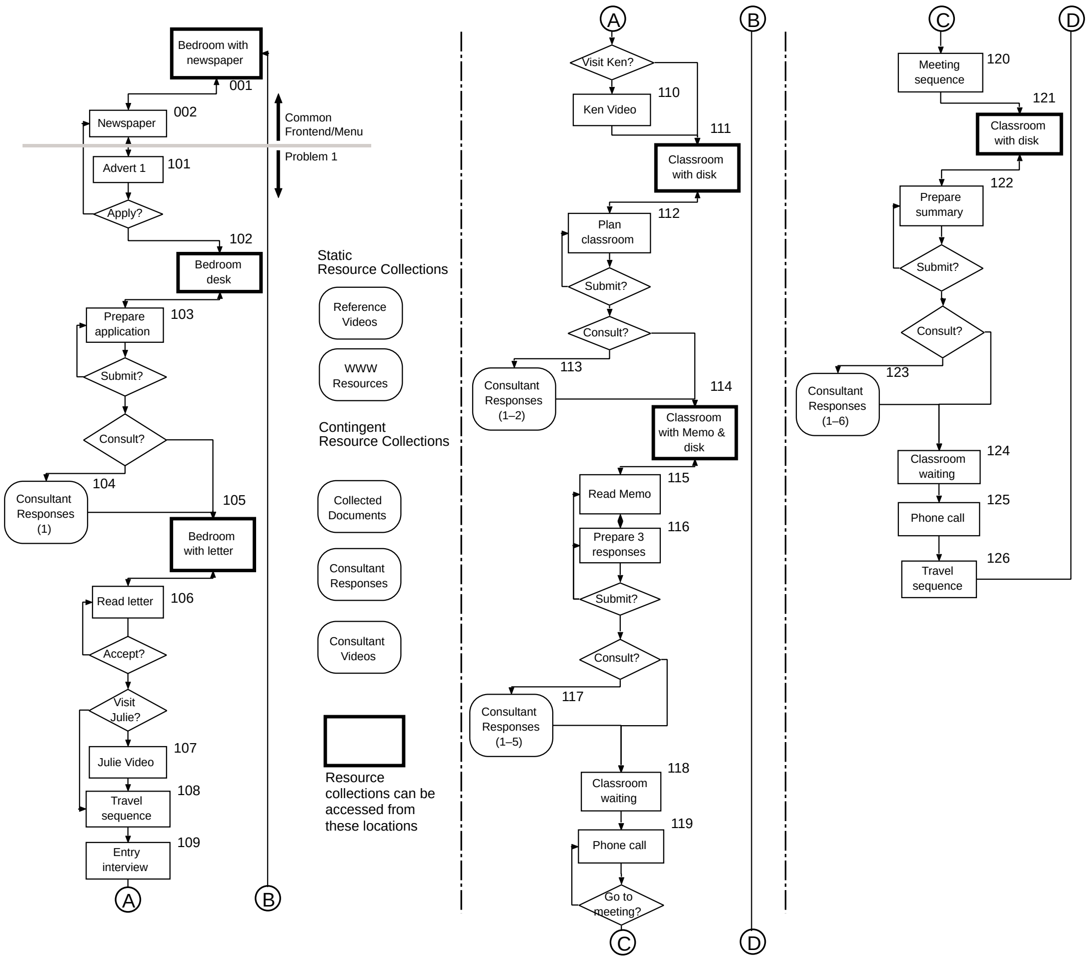

Figure 4.10: Flowchart for the web version of the first scenario

In addition to this flowchart, prior to development of the web version, a more detailed storyboard was prepared to clarify the content to be included on each screen. Figure 4.11 shows some typical screens as represented in the storyboard which was created using HyperCard to create a consistent appearance and to facilitate the use of text from files prepared previously and because of the ease of printing representations of the screens. Where the content in the main portion of the screen was to be other than text, notes and comments were included as guidance for the development process.

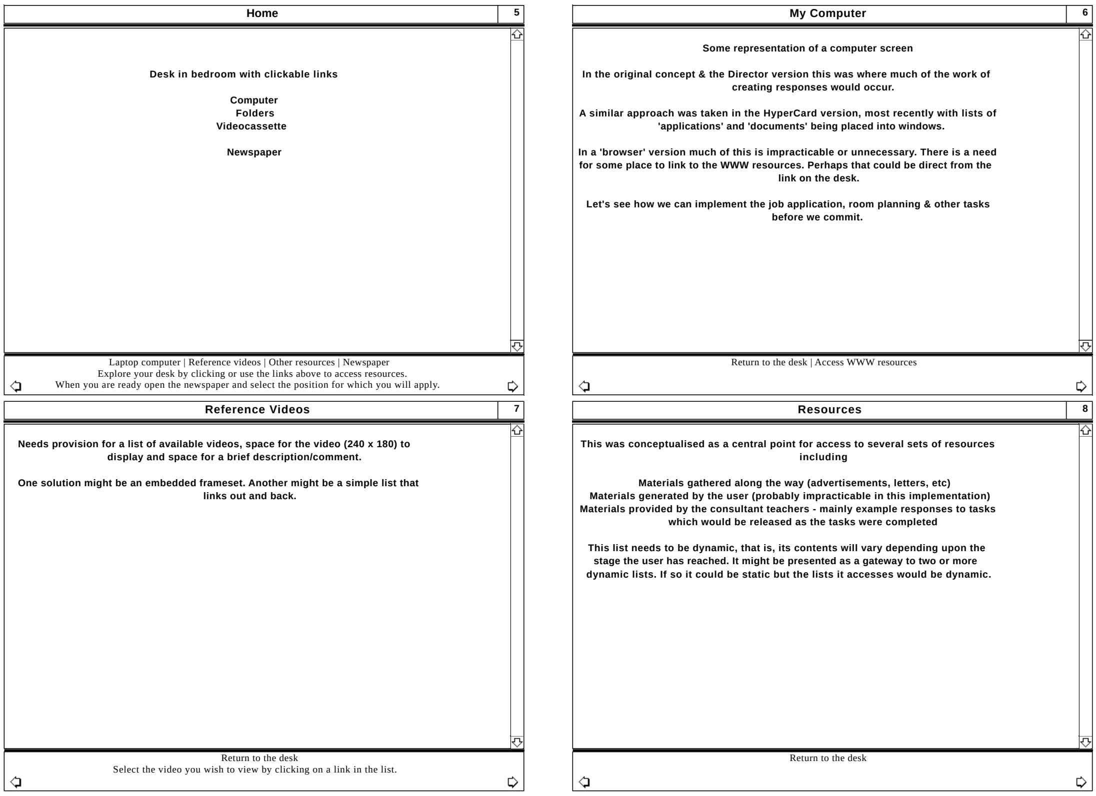

Figure 4.11: Storyboard for the web version of the first scenario

The tools and techniques used to document the planning process evolved through the course of the project in response to both the changing needs of the developers and the increasing levels of detail that became available. Each of the representations used in the project served a useful purpose in clarifying and documenting the design and providing guidance for the collection, preparation and incorporation of content.

4.6 Content selection and preparation

Alongside the evolution in the overall design of the IMM-PBL materials, there was a parallel evolution in the conceptualisation of the content resources to be included within the package. When the design process began the expectation was that the materials would offer rich representations of the problem scenarios with substantial amounts of contextual information, including video, audio, graphics and text. In addition there was an intention to provide a selection of resources which might be of use to students as they sought to develop responses to the problems.

Figure 4.12 represents the conceptual arrangement of resources in the completed IMM-PBL materials. As indicated in Figure 4.10 and Figure 4.12, the resources may be considered to be in two major categories, static and contingent.

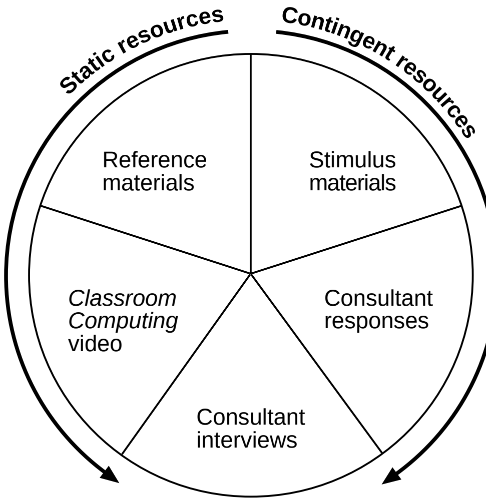

Figure 4.12: Conceptual arrangement of resources in the IMM-PBL materials

Static resources are those that are available to the user throughout the course of the narrative and may be accessed at any of the foci of interactivity (Plowman, 1996) which in the case of these IMM-PBL materials is any time at which the user is working at the desk at the points represented as bold boxes in Figure 4.10. They include reference materials and excerpts from a video production about teachers working with computers.

Contingent resources are those that relate directly to the narrative and are presented to the user as the narrative progresses. They include the documents, images, audio and video used to represent and provide context for the problems and the sample responses prepared by the cooperating teachers, referred to in the materials as consultants.

The videos of the interviews with the consultants are placed at the base of the diagram because they were treated as both static and contingent resources. They are available with the other static resources at any of the foci of interactivity but they are also presented at various times as part of the narrative stream.

The remainder of this section provides more detailed description of the resources in each of the categories identified in Figure 4.12.

4.6.1 Stimulus materials

One of the major benefits that multimedia can offer to problem-based learning is to enrich the representation of the problem and its context (Hoffman & Ritchie, 1997). The content elements included in the category of stimulus materials in Figure 4.12 are those used to present the problem, its associated tasks and the narrative in which they were contextualised.

Each of the scenarios was built around a sequence of events resulting from a successful application for a temporary teaching position. Once the outline of the scenario had been determined, the research assistants created appropriate content beginning with names of fictional schools, localities and characters in the story.

Documents prepared for a typical scenario began with the advertisement including selection criterion and extended to letters offering appointment as a teacher, school profiles, handbooks, development plans, policy and curriculum documents, e-mail messages and web pages. None of these was real but all were based on examination of documents obtained from schools and were intended to build up a convincing image of the school. Where appropriate, the programming of the IMM-PBL materials inserted the name supplied by the user to heighten the sense of personal involvement. Some documents, such as correspondence, included school logos prepared with assistance from the graphic artist.

Photographic images were used to provide additional contextual information. Each scenario included a short segment with three or four photographs portraying the journey to and from the school. Additional photographs portrayed school principals, other characters introduced in the narrative and selected physical features of the schools.

In each scenario the arrival of the user at the school was accompanied by an audio recording of a welcome from the principal and a description of the school. Other audio recordings were used to represent telephone calls and staff meetings.

The approach used to present the tasks in each scenario varied according to context. Documents such as a letter or memorandum were used in some instances. In others there was a telephone call or an e-mail message to draw the attention of the user to a pending task.

The collection or creation of these content elements was managed by the research assistants with final approval given by the project directors. Contextual material such as photographs of buildings or people (the principal and the staff meeting) were either selected from available stock or commissioned. Audio segments were scripted and recorded as required. Other materials, for example, the advertisement, letter of offer, school profile, school handbook, room plan and memorandum were created as required by the research assistants. As the content elements were prepared, they were reviewed by the cooperating teachers as a further check on authenticity and plausibility.

4.6.2 Reference materials

A second benefit of multimedia for PBL is the capacity to support timely access to reference materials (Hoffman & Ritchie, 1997). For the present project, the approach to inclusion of reference materials has been described previously:

> Because PBL is intended to increase the capacity of learners to solve real problems (Boud, 1985) and because identifying critical elements may be counter-productive (Savery & Duffy, 1995), the selection of resources for inclusion in the package is gauged to require judgement in selection from what

> is provided and initiative in employing material from alternative sources. (Albion & Gibson, 1998a)

The question of what reference materials might be usefully and conveniently included in the materials was considered early in the design process. It would have been possible to scan printed sources and include either the scanned images or documents converted by optical character recognition. Both posed minor technical challenges but the greater difficulty would have been in obtaining appropriate copyright clearances. Electronic sources, especially those on the World Wide Web, posed fewer technical difficulties but obtaining copyright clearance would entail considerable work if elements from a range of sites were to be included on a CD-ROM. The alternative of relying upon users accessing the sites from the Internet presented problems in ensuring that users had access to the Internet when using the materials. Moreover, there was the possibility of sites being removed from circulation.

Around the time this project was commencing, a number of relevant web sites were developed by Australian government agencies. The Open Learning Technology Corporation (1995; 1996a; 1996b) published a series of web sites comprising over 100 pages of material related to learning theories and the educational applications of information technology. Another national project produced a book and associated web site with over 40 descriptions of exemplary teacher practice in the use of IT in Australian schools (ACT Department of Education and Training, 1996). Approaches to the relevant authorities were successful in obtaining permission to reproduce the web sites in the IMM-PBL materials. These web sites formed the core of the reference materials to be included in the IMM-PBL package. They were supplemented by some selected links to sites on the World Wide Web.

4.6.3 Classroom Computing video

Although detailed planning of the multimedia materials did not commence prior to January 1997, the expectation that they would include video of exemplar teachers was clear from the outset. During 1996 the author was involved in the production of video material for use in teaching a subject about the use of computers in classrooms (Albion, 1996a). That production was based on short interviews with twenty teachers conducted across five primary and secondary schools. The schools were selected according to reputation for active use of computers in teaching and once contact was made with the school, appropriate teachers were identified in cooperation with the school principals.

Because it was anticipated that the video might be used in the proposed multimedia materials, copyright clearances were sought for that purpose as well as for the video production. Video of interviews and classroom activity totalling more than six hours was collected and, following identification of appropriate segments, was professionally edited to produce a forty minute program. Approximately thirty minutes of that video which was relevant to primary schools was later selected, digitised and included in the IMM-PBL materials as reference material.

4.6.4 Consultant interviews

Early in 1997 the Queensland Society for Information Technology in Education (QSITE) promoted a local one day conference about computers in primary education. Four of the presenters at the conference were local teachers who were making significant use of ICTs in their teaching and who were willing to share their work with colleagues. Following an approach by the author, they agreed to participate in the project by permitting a video crew to visit their classrooms to film class activities and interviews and by being employed temporarily to write additional content for inclusion in the IMM-PBL materials. Video footage of the conference presentations by two of these teachers was obtained but the conference schedule and other arrangements precluded video of the other presentations. A recent graduate who attended the conference and who was known to be commencing an Internet project with a class was also approached and agreed to participate in the same way as the other teachers.

Once the teachers had agreed to participate, formal approaches were made to the relevant schools for permission to film and the appropriate clearances were sought from parents or guardians to include footage of children in the IMM-PBL materials. The principal of one school suggested the names of two other teachers in his school who subsequently agreed to participate, making a total of seven teachers to be interviewed.

Because the interviews were to be included as video clips in the IMM-PBL materials and it was thought important to include contextual information, the interviews were conducted in the teachers' classrooms. This approach had been used previously in the development of instructional video materials which included teacher interviews (Albion, 1996a) and had been found to offer several advantages. Since classroom footage was required it was convenient for the researcher and the cameraman to obtain both classroom shots and the interviews at the same time. Conducting the interview in the classrooms meant that the teachers did not need to be withdrawn from class and minimised disruption to the schools. It also allowed the video of an interview to include visuals of classrooms which added contextual information for viewers.

Semi-structured interviews (Drever, 1995) were conducted using a schedule of questions (see Table 4.1) which was provided to the teachers in advance of the interviews but was not available to them during the actual interviews. Questions were asked by a researcher and the teachers responded on camera. The responses to the questions were spontaneous but in a few instances, where the teacher became uncomfortable with the direction of the response within the first few seconds, the tape was stopped and they were allowed to begin again.

Table 4.1: Schedule of questions for teacher interviews

1	How did you learn to use computers in your teaching?
2	What made you choose to use technology in your class to supplement traditional approaches?
3	What type of factors do you have to consider when planning for technology use in your classroom?

4	What classroom management factors must be considered with the addition of computers to your classroom?
5	Where do you go to get support, ideas for technology use?
6	How does the integration of technology into your classroom assist in achieving the objectives you set for your students? Have the objectives you use changed in any way?
7	What differences have you noticed in the outcomes for your students following the integration of technology?
8	What impact has the use of technology had upon your own approach to teaching?
9	What implications do you see for your classroom as a result of connecting to the Internet?

If a teacher was unable to respond immediately to a question, then it was slightly rephrased to prompt a response. In some instances, when a topic of interest emerged, an impromptu supplementary question was used to elicit further information. These questions and the responses were included in the interview transcripts which were prepared using the videotape records of the interviews. The transcripts were included with the video clips in the final version of the IMM-PBL materials.

4.6.5 Consultant responses

Implementations of PBL typically involve learners working in groups with the support of a tutor. Although the IMM-PBL materials might be used in such circumstances, one of the goals of the project was to present a PBL experience in a manner which would facilitate its use in distance or flexible learning (Albion & Gibson, 1998c, a).

If the materials were to be suitable for use by an individual learner then they must include some means of providing feedback to the learner following the completion of each task. The problems encountered by teachers are typically ill-structured, that is, there is no single correct solution but rather a variety of possible solutions. Hence, feedback in the IMM-PBL materials could not assume a single correct solution. Moreover, given that experienced educators do not always agree about solutions to problems of practice it seemed unlikely that software could be designed to offer appropriate judgements of solutions.

The IMM-PBL materials include up to six sample responses to each task prepared by the consultants who were interviewed as described above. As soon as the storyboard for each scenario had been prepared and the tasks had been defined, that material was distributed to the consultants who were invited to comment on the plausibility of the scenario and the relevance of the tasks, to offer suggestions for improvement and to provide sample responses for inclusion in the materials.

The IMM-PBL materials are constructed so that each time a user signals completion of a task, a table of links to sample responses is presented. Links to sample responses do not appear in the table until completion of the associated task is signalled. Thereafter those responses remain available to the user whenever other resources are accessible.

One of the difficulties associated with this approach to providing feedback to users is the quantity of text involved. With 23 tasks and six responses to each,

> there is potentially a total of 138 responses to be viewed. The vast majority, 120, of the tasks invited a response which is presented as text. A few are presented in novel ways and some are quite brief but the overwhelming impression is of a large volume of text, which, despite the value of the insights it affords into the thinking of teachers, is daunting in its sheer quantity.
>
> The problem in this instance was to encourage users to engage with the sample responses in a way that would promote learning. One advantage of the overall structure of the materials was that the responses relevant to each task were made available immediately after the task was completed and before the next segment of materials was accessed. Thus the materials were actively presented in small quantities at the time when they were most relevant. However, it was possible for a user to bypass some or all of the responses and although they were available thereafter they might not be viewed at all.
>
> To insist on users viewing each response before moving on would detract from the experience of user control and, even then, would not ensure that the material was meaningfully processed. The solution developed in this instance involved the creation for each task of a meta-response that summarised the responses from each of the teachers, highlighted similarities and differences and provided a guide to the key ideas which emerged in the responses to each task. Depending upon the particular responses, the meta-response might include both excerpts from the individual responses and links to key sections of the responses as well as commentary based upon other elements of the package. Users are able to gain an appreciation of the complete set of responses by reading just the meta-response and can choose to view some or all of the detail depending upon their interests and interpretation of the issues. (Albion, 1999c)

As responses were submitted by the consultants, they were collected by the research assistants who performed any file format conversions necessary to facilitate inclusion of the responses in the materials. The meta-responses were prepared by one of the research assistants and checked by the author.

4.7 User interface design

A multimedia package might contain compelling content and be driven by clever programming but its success with the user will ultimately depend largely upon the user interface. In common with other aspects of the design of the IMM-PBL materials, the user interface evolved in response to developing experience with the materials, changes in the development environment and the results of formative evaluation.

This section describes the significant characteristics of the user interface design. It begins with an overview of screen layout before focusing on the central navigational metaphor of the teacher's desk and the objects on it including the laptop computer, folders and video cassette. The arrangements for displaying the consultant's sample responses and help are described and the use of *intertitles* to assist the narrative flow is explained.

4.7.1 General screen and interface design

The overall design of the screen was influenced by both the evolution in design and the change in development environment for the final product.

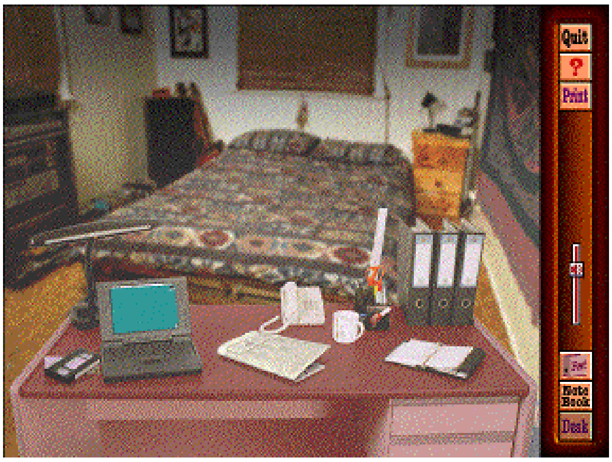

Figure 4.13: Typical screen layout in the prototype

The Director prototype was designed so that the application would completely fill a 640 by 480 pixel screen. On a larger screen it would be centred and the possibility of obscuring the surrounding screen was discussed. As shown in Figure 4.13, the prototype featured a navigation bar down the right hand edge of the screen. This feature was present on the majority of screens except when the space it used was needed for other purposes and an alternative means of navigation was available. Rollovers were used to draw attention to active areas on the screen and voice prompts were used at strategic points to advise the user about the next activity.

During the early discussions about interface design, concerns were expressed about how users might be assisted in going beyond a point and click exploration to begin work on the scenario tasks. The solution selected for implementation in the prototype was a "to do list". It was conceived of as a dynamic list that would indicate activities pending at any time during use of the materials and, by marking completed activities, also provide the user with a simple record of progress through the materials. A version was implemented in the prototype but, whether through misunderstanding of the design intent or programming difficulties, it did not function as the designers had envisaged. Instead of functioning as an aid or prompt to the user it was frequently the sole means of accessing the next stage of the scenario and almost every step through the prototype required a visit to the list. Other aspects of the prototype interface also lacked flexibility. For example, the computer and other objects on the desk were active only at the specific points in the scenario where the user was required to access them to advance. Overall, a user could feel constrained by the apparent lack of choice and control over the action with often just a single path available through the materials.

Such tight constraints on user action in the prototype were inconsistent with the intention of the designers. In the build used for the trials in October 1997, some of the interface limitations were understandable due to the short time available for development. However, the existence of the same limitations in versions created in March 1998, four months after the detailed review of the prototype had identified them as requiring changes, was troubling. These limitations and some persistent bugs contributed to the author's decision to build a demonstration version using HyperCard. That version addressed the issues in the prototype and was effective in demonstrating the intentions of the designers in respect of the user interface. However, because it was never intended for use other than as an aid to development, it is not further discussed here.

When development was redirected towards a web environment, there were implications for interface design. Because, depending upon the preferences of the user, the browser window would require space for menus and other features, the screen area available for the IMM-PBL materials was somewhat reduced. A decision was made to design for the most common 800 by 600 pixel screen but to hold images to a size that would permit limited use on older 640 by 480 pixel systems. As a consequence, images for use in the main panel were sized to 460 by 345 pixels.

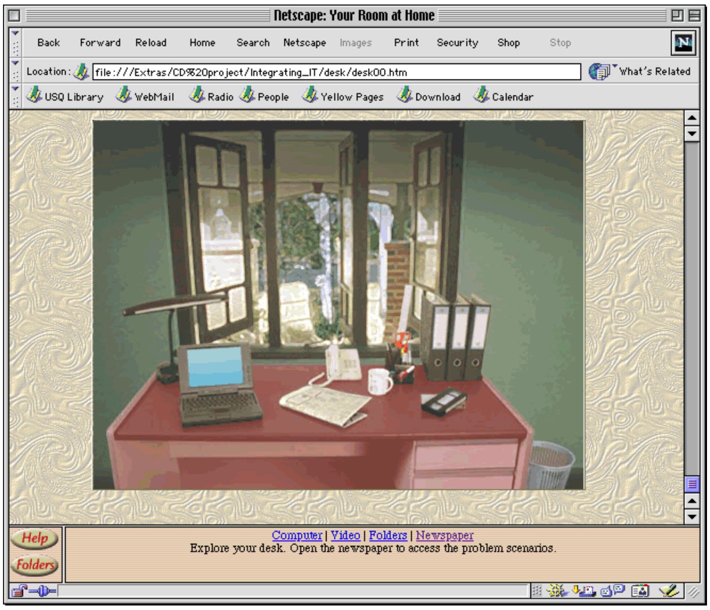

Figure 4.14: Typical screen layout in the completed version

Figure 4.14 shows the screen arrangement for the completed version of the IMM-PBL materials. As in the prototype, items on the desk were linked for navigation and rollovers were used to indicate which items were active, both by change in the cursor shape and by brief messages appearing in the prompt area at the bottom of the browser window.

Because users appear to find it easier to scroll vertically than horizontally, the navigation bar was placed in a frame at the base of the screen below the area where images and other content would be displayed. A smaller frame at the bottom left of the screen was reserved for a link to a help system. Following beta testing a second link was added in that area to facilitate access to the materials in the folders when the desk was not visible. A decision to use predominantly text links rather than images in the navigation area was taken for simplicity of implementation and to minimise the vertical space requirements. On screens where the image of the desk appeared with active links in the upper frame, the text links referred to the same items such as the computer or newspaper. The navigation frame height was set large enough to display a line of links and, depending upon the text size set by the user, one or two lines of text in which messages about the materials might be displayed. These messages replaced the voice prompts used in the prototype.

In the prototype, the entire application was presented within a single window. As part of the transition to the web environment the relative merits of using single or multiple windows was considered. Although in some respects a single window would simplify an interface by limiting the risk of confusing the user, it was thought that, on balance, the additional convenience of multiple windows outweighed the risk of confusion. Once accustomed to the system, users would be able to work in one window while referring to material in another without constantly shuttling between different screens displayed in a single window. Moreover, the use of multiple windows was expected to reinforce skills and confidence for working more generally with ICTs. Hence, functions such as Help, the computer, the folders and the video viewer were constructed to open in separate windows. Where programming in the particular browser version supported the appropriate controls, the links to open windows were programmed such that the window opened at a different size and position and on top of other windows to assist the user in attending to its appearance.

4.7.2 The desk

Because the problem scenarios were to focus on planning for teaching with ICTs, an early decision was taken to use a desk metaphor as a central navigational element in the software. Items on the desk provided access to resources to be used in preparing solutions to the problems. The opening screen of the pre-prototype shown in Figure 4.4 featured the desk as the centre of action. The desk remains as a central feature of the interface in the completed version and is present in each of the key locations shown in bold in Figure 4.10.

Figure 4.13 and Figure 4.14 show the desk as it appears in the screens at the beginning of the scenarios in the Director prototype and the completed web version of the IMM-PBL materials, respectively. Both figures are reproduced at approximately the same scale. Whereas the Director version could extend to the limits of the application window, the image of the desk in the web version has been reduced in size to accommodate the surrounding browser window and other features of the interface. In terms of navigational elements present on the desk, the two versions are identical. However, there are noticeable differences in the graphic design treatment. The final version uses lighter colours and looking out the window rather than into the room is intended to induce a greater sense of openness to new experiences.

As envisaged during the planning of the prototype, the desk was to include, as consistent navigational devices, the items and associated functions listed in Table 4.2. In addition, there were some items such as a coffee cup which were consistently present but had no navigational function. Other navigational items such as a newspaper might be present or not according to context and the desk drawer might sometimes contain documents relevant to a particular context.

Table 4.2: Navigational functions of standard items on the desk

Item	Facilities accessed
Telephone	Persons represented in the materials via incoming and outgoing calls
Notebook	Note-taking facility
	Record of personal progress through the materials
	"To do list" function for guidance through the materials
Books	Texts such as policies and readings
Video cassette	Excerpts from the *Classroom Computing* video
Laptop computer	Computer presented reference resources
	Software tools for preparation of solutions

The functions of several of the navigational items listed in Table 4.2 were subject to revision during the development process.

The telephone continued to be active when audio segments representing incoming telephone calls were used to prompt a user action. However, the final plans for the scenarios did not require any outgoing calls and in the completed version the telephone is inactive except for incoming calls.

When the use of print sources for references was abandoned, the books were no longer relevant for their original purpose. They were replaced by a set of folders with functions as described below.

A simple note taking facility was included in the prototype but implementation of a similar facility in the web environment was problematical. The notebook was dropped from the final version on the basis that users would be better served by using whatever note taking software was provided by their computer system which would offer better facilities and the benefit of learning skills that were applicable for future use.

4.7.3 The laptop computer

The use of the computer for access to reference materials was expanded when the anticipated use of references imported from printed sources was supplanted by the use of web sites as described above. When the computer is invoked by clicking on the image or the text link a new window opens with a simple image of a computer screen. Depending upon the context there will be one or more links that appear as icons in the "computer" screen. Figure 4.15 shows a typical instance of the computer window.

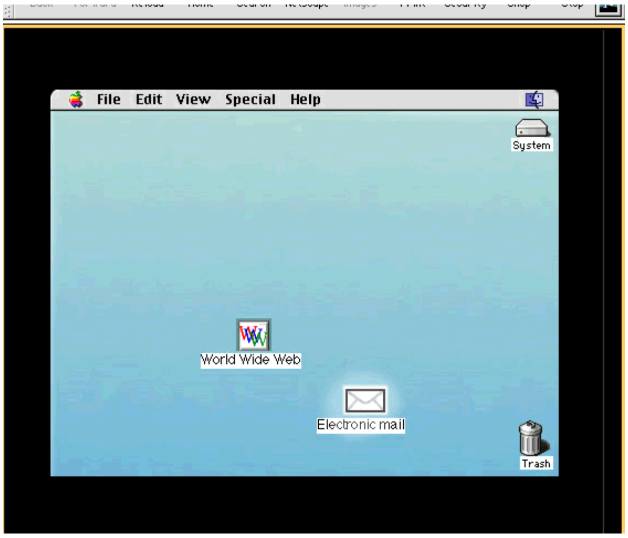

Figure 4.15: Typical view of the "computer" window

The project directors had anticipated creating a self-contained learning environment which would provide users with all necessary tools. As the design evolved to focus on tasks which entailed creating artefacts associated with planning for teaching,

> many of the artefacts to be produced by users required the creation or editing of text. Although it would be possible for users to prepare their responses with pen and paper, the goal of increasing their confidence in using ICT would be better served by having them use the computer.
>
> Macromedia Director provides for fields in which text may be entered and edited. The text can also be saved and retrieved. However, the default condition as used in the initial prototype offered only the most rudimentary editing facilities and did not include formatting tools to support creation of well-structured documents. The facilities available in a text entry area on a standard web page are, if anything, more limited and do not permit easy saving and retrieval. In the final version some sections do make use of web page text entry fields but these are in contexts (simulated email and web form completion) where the limitations are realistic.
>
> The absence of acceptable text editing facilities was regarded as a significant disadvantage in a package intended to improve the learner's facility with ICT. Developing a more capable, but still limited, editor within the total package was considered and rejected on the grounds that the restricted benefits would not justify the investment of resources. Requiring users to work with a text editor or word processor external to the package offered substantial benefits for formatting and for building confidence with ICT but would add an extra layer

of complexity for the user. On balance, at that stage it was thought preferable to work with the limitations of the internal editor for the sake of simplicity.

When the decision was made, for other reasons, to move development to a web-based format, the text editor issue was reviewed. The limitations of working within the text entry area of a web-page were considered too restrictive and it was decided to have users accept responsibility for selection of their own text processing environment and for management of their own files. They were also offered the possibility of accessing prepared files in a choice of formats (Word or RTF) that provided templates or structured starting points for the preparation of their responses. This solution provides a level of support while encouraging users to become more familiar with the use of their own software and thus matches well with the overall goals of the package. (Albion, 1999c)

4.7.4 The folders

The folders were introduced in the prototype as a means of representing the collection of materials encountered in the course of working through a scenario. Documents such as the advertisements, correspondence and policies were to be linked from the folders as they were encountered.

When development was transferred to a web environment there were some additional issues to consider. The hypertext paradigm of the web promotes freedom of movement at the discretion of the user. As is evident from the flowchart in Figure 4.10, the IMM-PBL structure is based on a series of nodes ordered in time by a narrative and through which the user moves. Free interaction with the resources is largely restricted to the nodes. Although the web browser has a history mechanism which facilitates return to a previous location, the use of that facility was considered undesirable because of the potential for a user to become lost and unable to return to the location at which they had been working. It is technically possible to suppress the browser history function but it was considered better to retain the standard browser behaviour and to discourage its use by providing a more convenient mechanism through the folders.

Thus, the primary function of the folders is to enable the user to access resources they have already encountered on their passage through the scenario. To assist users in connecting the resources to their contexts, the collected materials are arranged by scene in the order in which they were encountered. This arrangement provided a reasonable alternative to the recording function that had been proposed for the "to do list". Because the forward-looking sequence of events was already implicit in the programming, it required little work to have the folders display an outline of key events in each scenario with the resources added to the list as they were encountered. Adoption of this mechanism enabled the "to do list" to be abandoned.

The folders also provide a point of access to information about the consultants, including biographical notes, links to the interviews and links to the collection of sample responses appropriate to the stage the user has reached in the scenarios.

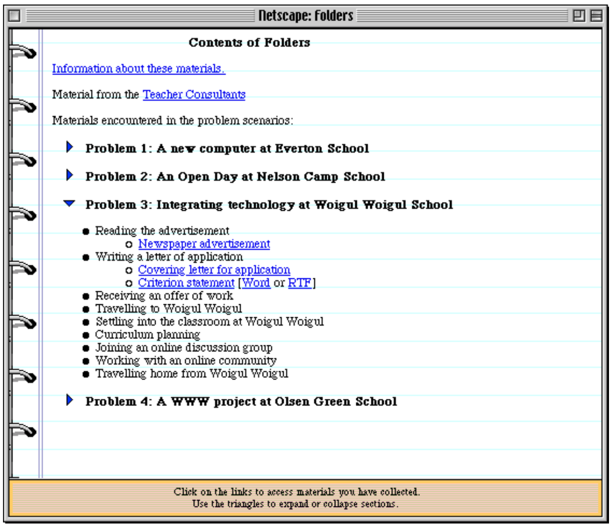

Figure 4.16: Typical display in the folders window

Figure 4.16 shows a typical display as seen in the folders window. The links at the top of the screen are to the internal documentation about the IMM-PBL materials, including acknowledgments, and to an area from which the consultant screens can be accessed. The remainder of the display is devoted to accessing materials found in the scenarios.

To avoid excessive scrolling, the list is designed to expand and collapse. Initially it collapses the lists for all scenarios other than the current one. Expansions or contractions initiated by the user clicking on the triangle shapes persist even if the window is closed and opened again. Materials encountered through the scenarios are added in indented sub-lists at the appropriate locations.

The folders are an important component of the interface because they provide access to a range of materials that may be required by the user when working on tasks. When it became apparent from beta testing that some users had not been accessing the folders, a permanent link to the folders was inserted in the help link area at the bottom left of the screen.

4.7.5 Displaying video clips

Video clips may be displayed in several different contexts within the IMM-PBL materials. The video cassette which appears on the desk offers access to the excerpts from the *Classroom Computing* video within a separate window. At various points in the narrative one or other of the consultants is introduced as a character and the relevant interview is presented within the main window. These same interviews are also available from within the folders and in that case are displayed within the folders window.

For consistency, the same format is used for displaying the video in each instance. Figure 4.17 shows the video interview display within the consultants' area that may be accessed from within the folders. The bottom frame provides links for convenient access to information about the other consultants or to the previous location.

Figure 4.17: Display format for video interviews

The standard arrangement for display of an interview comprises four frames. At the top, using white text on black for contrast, is a label identifying the video subject. Immediately below that the window is split in halves with the video displayed in a frame on the left and the transcript (or notes if there is not a transcript) displayed in a scrolling frame on the right. The frame below displays a list of links to be used to select the video clip. In the case of the interviews these links comprise the text of the questions.

4.7.6 Displaying consultant responses

As discussed above, the consultants' sample responses to the tasks are mostly text and number over 100 in total with up to six presented for each task. The interface for accessing the responses needed to make it as convenient as possible for the user to locate and access a response and to compare that response with other responses to the same task or from the same consultant. The meta-responses described above were introduced to assist in this respect.

Figure 4.18 represents the typical appearance of the consultant response area. For consistency the display is similar whether accessed in the course of working through a scenario or from the folders, which it has been in this instance as indicated by the return link in the bottom frame.

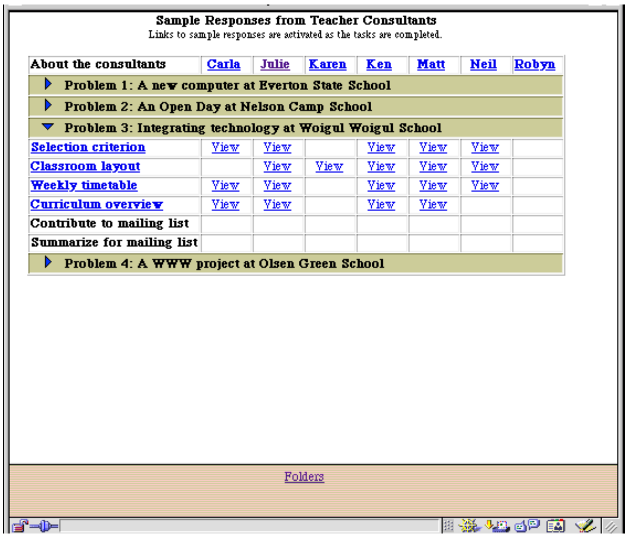

Figure 4.18: Format for display of consultant responses

The table sections for each problem scenario expand and collapse in a similar manner to the lists in the folders. The names of the consultants appear in the top row and are linked to pages containing biographical data and further links to information about the consultants including the video interviews. Responses to a single task are in a row and those by a consultant form a column, rendering it possible for a user to easily compare responses to each task from different consultants or to examine a single consultant's responses to a series of tasks. The meta-responses are linked from the task identifiers in the left-hand column. Once a response is selected the bottom frame changes to include an indication of which response is being viewed, links to each of the responses in the same row and a return link to the table. This arrangement, which is depicted at the base of Figure 4.17, provides single click access to other responses to the same task.

4.7.7 The help system

The help system can be accessed at any time by clicking the button which appears in the lower left-hand corner of the main window. It opens in a separate window so that it can be referred to while working in another window.

There are two principal divisions. One, a glossary which provides definitions of approximately sixty terms which are used in the IMM-PBL materials and which may be unfamiliar to users, is a single page with an alphabetical index for ease of access.

The second part of the help system is further divided into two parts. There is a general help area that provides information about operation of the materials including how to navigate and how to use the various controls. The remainder of the help is contextual. That is, when the user clicks the help button the software checks the location of the user in the system and returns the relevant page. There are pages for each of the tasks and for certain other elements, such as video clips, which appear in the main window.

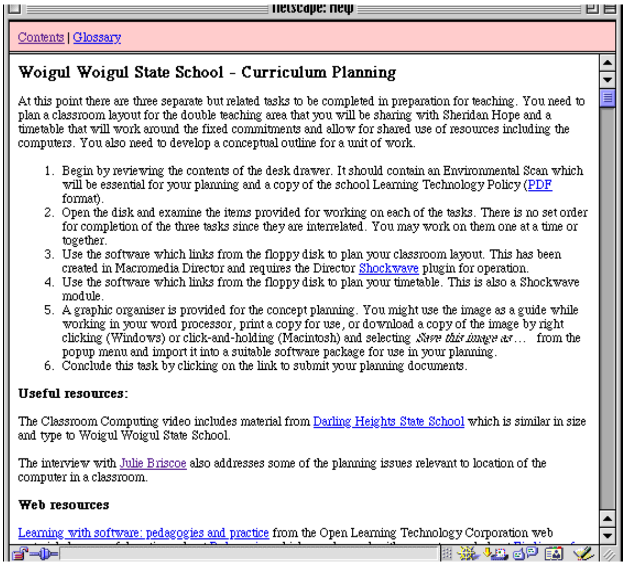

Figure 4.19: Typical display of help for a task

Figure 4.19 shows the display generated by a request for help made while the user was working on a task. Help screens for tasks typically begin with a statement about the task and its goals. That is followed by a step by step description of how the task might be approached. In some instances images are included to illustrate the operation of the software. The help for each task also includes suggestions about resources which might be of assistance with links to sources within the materials or on the Internet.

4.7.8 Use of intertitles

The design of the IMM-PBL materials is based around a narrative within which the various tasks are situated. Care was taken to ensure that the tasks were well integrated into the narrative and that they were "in short, discrete units which arise logically from the narrative" (Plowman, 1996, p. 103).

The unfolding of the narrative is implicit in the sequencing of the documents, images and other stimulus materials. However, Plowman (1994) found that some users who were unfamiliar with the conventions of multimedia experienced difficulty in working with it. She suggested that there were parallels between the early history of film production and the current stage of multimedia development. Drawing on the methods of early film, she suggested the use of techniques such as *explicadors* and *intertitles* to make the narrative structure more explicit while users are adapting to the new forms.

The prototype had made use of voice prompts at key points such as the change of scene. These fulfilled a role similar to that of an *explicador* as described by Plowman (1994). The complete IMM-PBL project would have required a large number of voice prompts to be scripted, recorded, digitised and worked into the materials. Moreover, the usual mode of using audio would have resulted in users having just one chance to hear and understand the message with no opportunity for review. Hence, in developing the web version the audio prompts were replaced by short texts placed on screens appearing between key locations. These texts performed a role similar to that of *intertitles* in early films (Plowman, 1994).

4.8 Materials assembly and programming

The completed IMM-PBL project comprised almost 2300 files which varied in size from fewer than 100 bytes for a small HTML file to over 40 Megabytes for one of the longer video clips. Table 4.3 summarises the files in the completed project according to type and source.

Table 4.3: Number of files by type and source

Type of file	Source	Number
QuickTime video clips	DEC	103
Other media elements	DEC	90
HTML and images	Imported sites	434
HTML	Author, generated using ILS-ML	744
HTML	Author, generated using Filemaker Pro	341
HTML	Author, created or converted and formatted	436
PDF, Word & RTF	Author, created or converted and formatted	42
Images	Author, created or converted and adapted	106
Total		**2296**

Approximately 2000 lines of JavaScript program code were written by the author and inserted into files. The functions performed by this code ranged across tracking user progress, inserting the user name into appropriate screens, managing the display of materials in the folders and consultants' areas, and simulating e-mail interactions.

The remainder of this section will describe the techniques used by the author to create, assemble and program the files that make up the completed IMM-PBL package. Most of the work undertaken by the author was performed on Macintosh computers. To ensure cross platform operation, regular testing was conducted in Microsoft Windows, most frequently using Windows 98 in the Virtual PC emulation environment. Additional testing in native Windows systems was performed periodically.

4.8.1 Creating the web site

Interactive Learning Services Mark-up Language (ILS-ML) is a method devised to enable content experts working in a familiar environment, typically Microsoft Word, to prepare documents which can be automatically converted into complex web sites (Evans, 1998). The name derives from the section within the Distance Education Centre at the University of Southern Queensland where the system was devised.

The ILS-ML system comprises two parts. The first consists of a collection of *tags* or additional instructions which can be embedded in a document which is prepared using the Hypertext Mark-up Language (HTML) on which the World Wide Web is based. The second is a computer program that reads the marked up file and, using the embedded instructions, creates a collection of web pages based on a template.

ILS-ML was used to create the basic framework for the IMM-PBL project. For example, it was used to create most of the pages implied by the flowchart for the first scenario as shown in Figure 4.10. The decision not to commit the entire project to ILS-ML was based on the need to apply individual formatting to many of the elements including the consultant's responses and the difficulty of managing those requirements in a system designed primarily to create large sites based on a single template.

The use of ILS-ML saved considerable work in preparing the almost 200 pages in the basic framework. The apparent discrepancy between this number and the 744 files shown in Table 4.3 is explained by the structure of the pages. Each page is an HTML frameset requiring a total of four files. One file describes the structure of the page and each of the three frames in the page displays another file. In the case of these materials the lower-left frame always displays the same file with the links to the help system and folders. Most of the images and the Shockwave applications prepared elsewhere were incorporated in the pages generated using ILS-ML.

Because the automatic generation of the base pages using ILS-ML had been successful, a similar approach was sought for creating the pages which would display the 103 QuickTime video clips. The interview question, transcript, file name and other details for each clip were recorded in a Filemaker Pro database. Hence a decision was made to attempt to generate the framesets and pages, including links to load the videos, direct from the database. Filemaker Pro has its own internal scripting system but that system is not easily able to create files. Instead the author created a program using AppleScript to create the appropriate HTML files.

The research assistants prepared stimulus materials according to the plans developed by the project team and collated sample response prepared by the consultants. This material was developed and stored in a variety of file formats requiring conversion to file formats suitable for presentation in a web browser environment. Much of the material also required light editing to eliminate typographical errors or to clarify expression, and formatting to ensure reasonably consistent appearance in the final product. The author performed this work using a variety of software tools including word processors, text editors, HTML editors and graphics programs. In order to preserve formatting which could not be easily rendered in HTML, some files were converted to PDF or graphic images. Others, such as templates made available for users to download, were prepared in multiple formats to accommodate the needs of different users.

In addition to the content prepared for conversion by the research assistants there was a considerable quantity of other material to be created or converted for presentation in the web browser. The help system, folders, laptop computer including the e-mail simulations and other minor elements totalled around 200 files to be created and formatted for the screen. Some of these files required the preparation of embedded images including images of working screens from the materials for use in the help system and buttons or other interface elements in the e-mail simulation.

4.8.2 JavaScript programming

JavaScript first appeared in Netscape browsers but is now available in both Netscape and Microsoft browsers for Windows and Macintosh platforms. Moreover, as part of the standard browser environment, it requires no additional installation. Hence, it was a logical choice for programming the mechanism to track users through the materials and control access to resources such as the sample responses. Its use also permitted the addition of features such as rollovers to highlight linked images, insertion of the user's name into document displays, expanding lists as used in the folders and consultants areas and the e-mail simulations used in scenarios three and four.

Programming in JavaScript presents some significant challenges. To date there appears to be no universally agreed standard for the JavaScript language and its implementation. Netscape and Microsoft have created slightly different versions of JavaScript. Neither is entirely consistent between Windows and Macintosh implementations and the language continues to evolve with each new browser version. As a consequence, any project using JavaScript to prepare pages that may be viewed in either Netscape or Microsoft browsers on either Windows or Macintosh must test in at least four environments. Even then there may be unanticipated variations in the JavaScript language that will cause a program to fail.

The JavaScript code for this project was created using a simple text editor on a Macintosh computer. Because the Netscape browser has better facilities for error checking and debugging, it was used for initial testing. The code was tested and revised until it was known to work reliably in Netscape on the Macintosh. It was then tested using Microsoft Internet Explorer on the same system and a further cycle of revisions and testing followed until the code was working consistently in both Macintosh browsers. The code was then tested using both browsers in the Windows environment and further revisions were made if necessary until it worked in both browsers under both operating systems. For convenience, the Windows testing of JavaScript code was typically carried out by placing the files on a web server from where the same file could be accessed from any of the test systems. The latter practice resulted in a significant problem with the version of the software prepared for beta testing. The problem and its resolution are described below.

All of the significant applications of JavaScript in the IMM-PBL materials involve the capacity to retain data generated during the display of a page for at least a short time after that page is removed from display. In the case of the mechanism for tracking a user in the materials, it is desirable to be able to retain data between sessions at the computer. In some other instances, such as the state of the expanding lists, it would be sufficient to retain data during a single session.

Retaining data between user sessions relies upon the browser cookie mechanism. A *cookie* is a small segment of text which the browser is permitted to store on the user's computer. The mechanism is constructed so as to prevent access to that data by a source other than the one that initiated its storage.

When a user begins working with the IMM-PBL materials, there is a request to login. JavaScript in the login page checks to see if there is already a cookie with that name and, if so, offers the user a choice of resuming in the previously recorded location or commencing again. If there is no cookie with the login name, one is created. Each key page in the materials reads the cookie and updates it with information about the location reached. These data are also read by the folders and consultants' pages to determine which data should be displayed.

Cookies may be used to store and retrieve data generated during a user session but there are alternative mechanisms. The IMM-PBL materials are presented in framesets and, in such parts of the materials as the folders, consultants' pages and the e-mail simulation, the one frameset file is used as a container for a collection of pages which may be displayed in sequence according to the links selected by the user. In these areas it is possible for data to be stored using a variable in the frameset file and passed between the frameset file and the files it displays using JavaScript code. This system was adopted for those parts of the materials which did not require data to persist between sessions.

When the beta version was tested, it became apparent that the approach described in the previous paragraph worked in all of the browser and operating system combinations except the Windows version of Microsoft Internet Explorer. Even then the system worked if the files were being accessed from a web server but not if they were loaded from a local drive. The preliminary trials had worked because they were conducted using files on a web server. The problem was in the implementation of the browser security model and no simple solution could be found. Consequently those parts of the JavaScript code which used that mechanism were rewritten to use cookies for passing information among pages.

4.8.3 CD mastering and replication

CD mastering and replication for both the beta and final versions were handled by staff within the Interactive Learning Services section of the USQ Distance Education Centre.

In each case the author delivered the total set of files collected in a directory structure on a hard drive. Staff from ILS added the files required for various installers and ancillary systems, prepared the CD master and arranged for replication.

Chapter 5: Results

The results obtained by the various methods described in Chapter 3 are presented in a sequence based on the description of the methods. Thus data collected in the validation processes will be presented first, followed by that from the prototype trial, the beta evaluation and the evaluation trial, in that order.

5.1 The IMM-PBL materials

The IMM-PBL materials themselves constitute the first result from the project. A CD-ROM containing a copy of the materials forms a significant part of this dissertation.

5.2 Design and content validation

Two sets of data are presented in this section. The first is the data obtained from a questionnaire directed towards potential reviewers with knowledge and experience of PBL. The second represents an analysis of the text of the interviews with teachers as presented in the IMM-PBL materials.

5.2.1 PBL practitioners' responses to the IMM-PBL materials

Requests made to experienced PBL practitioners directly or through the PBL mailing list resulted in six completed questionnaires. Table 5.1 summarises the data on their PBL background and experience. References to specific universities and other identifying data have been removed or generalised.

Table 5.1: Experience cited by PBL practitioners panel

Respondent	PBL experience
A	Introduced PBL foundation and advanced units in computer science at a major metropolitan Australian university.
B	Taught PBL classes at another major metropolitan Australian university since receiving PBL training in 1995, used web resources for PBL teaching including one class entirely online.
C	Seven years experience of teaching PBL classes for dental students at an Australian university including experience in computer-based problem development since 1994 and an interest in conversion to web-based modules.
D	Ten years of experience with PBL, including a 3 month sabbatical with Howard Barrows in 1995 and currently director of PBL curriculum at a medical school in the USA.
E	Conducted several workshops on PBL, published several articles and used PBL in teaching for several years.
F	Background in traditional instructional design including CD-ROM and online multimedia courseware. Three years researching and practising constructivist methods of teaching with particular interest in models of online design working on a model that incorporates PBL with tutorials and other learning assets in an online environment.

Although only a small number of responses was obtained, the respondents appear to be well qualified by experience to comment on the degree to which the IMM-PBL materials exhibit the characteristics of PBL. All six respondents (3 males and 3 females) were members of university faculties, three in Australia, two in the USA and one in Canada. All possessed doctoral qualifications, most were relatively senior academics (senior lecturer or equivalent) and all claimed significant experience in the use of PBL within their subject areas, which included medicine, dentistry, computer science and teacher education.

Table 5.2 summarises the responses to the numerical scale for individual items on the questionnaire. Where an individual did not respond to a particular item that has been indicated by recording "nil".

Table 5.2: Responses to PBL practitioners questionnaire

		SD 1	D 2	N 3	A 4	SA 5	Nil	Median
1	The materials present a problem as the starting point for learning.				3	3		4.5
2	The problems presented in the materials are relevant to the future professional lives of teachers and provide a meaningful context for learning about teaching.			1	2	1	2	4.0
3	Materials of this type could be used in a sustained educational approach and not simply as an atypical insertion in an otherwise conventional educational experience.				2	3	1	5.0
4	The materials are consistent with an approach in which learners assume significant responsibility for their own learning.				5	1		4.0
5	The materials would encourage learners to become active processors of information.				4	2		4.0
6	The materials would provide opportunities for learners to activate prior relevant knowledge.				2	3	1	5.0
7	The materials would provide opportunities for learners to elaborate and organise their knowledge.				4	1	1	4.0
8	The materials are consistent with an approach in which knowledge is organised around problems rather than disciplines.			1		4	1	5.0
9	The materials are consistent with the experience of learning in small groups rather than through lectures.		1	1	3		1	4.0

It seems clear, from the pattern of responses and the median values for individual items, that there was consensus among the respondents that the IMM-PBL materials matched the listed characteristics of PBL. The only item to receive a response registering disagreement was item 9, which referred to learning in groups. Missing responses, for example, in item 2 about relevance to teaching, occurred where respondents felt unable to respond to the particular item. Additional insights may be found in the comments made in general or in relation to individual items. These are summarised below.

Two of the respondents offered general responses not attached to any specific item. At the end of a description of PBL experience, respondent F commented "I find your approach refreshing … and one of the best examples that I have seen presented online". Respondent E commented that the materials were well done and enjoyable but might be too directive and offer insufficient encouragement to users to work with a variety of resources to qualify as PBL. The comment also noted that the opinion was based on only the first task, which involved writing to the selection criterion.

Few comments were offered in relation to item 1. B commented on the similarity of the problems. D thought the problems sufficiently ill-structured to qualify as PBL. F suggested more simulation to engage the user and commented positively on the use of the desk.

Responses to the second item mostly included a comment to the effect that relevance was difficult for a non-teacher to judge but that the problems appeared relevant.

On the issue of using such materials in a sustained approach, B suggested that PBL could become routine if not sufficiently varied. C agreed that it could be used widely but that the cost of production would be an inhibiting factor. C also suggested the use of face-to-face or computer mediated interactions to supplement the materials.

The only substantial comment on item 4 was from C who supported the use of expert feedback as in the consultants' sample responses and suggested that the addition of some level of individual feedback would assist users in learning to self-evaluate. C also questioned the degree of scaffolding and wondered to what extent it was faded as the problems progressed.

In response to item 5, which referred to active processing of information, D noted that the materials used the three conditions of learning, namely, recall, encoding and elaboration. C commented that students "could work through these scenarios at a range of levels, not all desirable unfortunately" and A expressed doubts about whether students would work through the materials thoroughly.

On the question of activation of prior knowledge, B wondered about encouragement to users to access prior experience such as voluntary work not directly related to the context of teaching. C thought that the scenarios provided for this well and that the scaffolding and expert feedback would help users to recognise things that they may not have realised were related or useful.

In relation to elaboration, C commented that the opportunities were provided but that the degree of elaboration and organisation was controlled by the scaffolding provided. Again, C thought that the expert feedback would be helpful to students.

Comments from B and D about item 8 agreed that the knowledge was organised around problems and F thought this came across "very strongly".

Item 9 related to support for group work and drew some of the strongest comments. A questioned where was the support or motivation for working in groups which was seen as a critical part of the PBL process. B agreed that the materials were consistent with working in groups but did not require it and added that students often fear group work and avoid it unless they have strong incentives. C suggested adding steps to encourage comparing responses with members of a group and F noted the absence of elements of team collaboration but added that a mixture of individual and team problems would be effective.

5.2.2 Consultants' perspectives on teaching with computers

The video clips of interviews with the consultants (co-operating teachers) were an important element of the design of the IMM-PBL materials. Their inclusion was directly related to two of the IMM-PBL design principles derived in Chapter 2, namely, incorporation of relevant cases and representation of multiple viewpoints. Moreover, responses from participants in the prototype trial (see below) revealed that a majority of them nominated the video interviews as their favourite element in the materials. Hence, although the primary purpose of obtaining the interviews was for their inclusion in the IMM-PBL materials, it was important to confirm that they presented appropriate models of computer-using teachers and conveyed appropriate messages about teaching with computers. Thus, analysis of the interviews was undertaken as a means of investigating how the views presented in a significant part of the IMM-PBL materials compared with the findings of research on computer-using teachers.

Using the procedures described in the Chapter 4, the seven teachers who cooperated as consultants on the development of the IMM-PBL materials were interviewed. They are referred to here by the pseudonyms adopted for the IMM materials. Background information about the teachers and their working environments is presented first and is followed by an account of the interview data.

5.2.2.1 The teachers and their working environments

Brief biographical notes are provided below for each of the teachers and a summary of key characteristics is provided in Table 5.3.

Table 5.3: Characteristics of the teachers and their workplaces

Teacher	Gender	Experience (approx)	School	Type	Year level	Classroom Computers
Carla	Female	>10 y	A	Non-government	3 - 7	Laboratory (10 computers)
Julie	Female	Beginning	B	Non-government	4	1 in classroom
Karen	Female	>15 y	C	Government	6	5 shared in a withdrawal room
Ken	Male	>15 y	C	Government	5	1 in classroom
Matt	Male	15 y	D	Government	7	2 in classroom
Neil	Male	>20 y	C	Government	4	5 shared in a double room
Robyn	Female	4 y	E	Government	1 & 2	Laboratory (15 computers)

Carla has studied theatre and is a qualified secondary teacher. She has used personal computers as productivity tools for more than ten years. At the time of the interview she was working part-time as a specialist teacher of computing with years three to seven children in a non-government primary school and studying information technology at university. Carla's role in the school included planning and conducting classes for children in the ten seat computer laboratory and assisting other teachers to develop skills and adapt curriculum to integrate computers.

Julie had just commenced her first teaching appointment at the time of the interview. She graduated as a primary teacher with a degree that included several information technology subjects. Julie's year four class in a non-government school was beginning a Travel Buddies (RITE Group, 1998) project in which they exchanged stuffed toys and e-mail messages with a class in a New York State public school. She had commenced the project using a computer in the school office and had a computer installed in her classroom the day the interview was conducted.

Karen is an experienced teacher who has had an interest in teaching with computers for several years. She has provided leadership for computer use in the government school where she works and began using the Internet with her classes as early as 1993. At the time of the interview she was teaching a year 6 class. Karen's class and the class in the next room shared a mini-laboratory of 5 computers in a withdrawal room between the two classrooms.

Ken has taught in primary schools for more than 16 years. At the time of the interviews he had been using a computer in his teaching for about four years. He is an active member of the Queensland Society for Information Technology in Education (QSITE). Ken gave a presentation to a conference for local teachers based on his experiences in using a single computer in his year four classroom in the same government school as Karen and Neil.

Matt has been teaching for fifteen years and is known in the local area as an innovative user of computers in his teaching. In one of his most interesting projects, a year six class developed a web site to promote a local tourist attraction. At the time of the interview he was teaching a year seven class in a government school and had two computers available in his classroom.

Neil has about twenty years of teaching experience. At the time of the interview he was teaching year four in a double teaching space with five computers shared by the two classes in the double space. Neil has been working with computers in his teaching for a relatively short time in the same government school as Karen and Ken.

Robyn has been teaching for about four years. Her preserve course included four optional subjects dealing with the educational use of computers. At the time of the interview she was studying for a masters degree with a major in educational computing and was teaching in a small government school on the fringe of the city. Robyn's role in the school included establishing and coordinating the operation of a computer laboratory. She has conducted inservice workshops on computing for teachers in local schools.

There is no suggestion that these teachers are necessarily typical of computer-using teachers, nor that they are a representative or random sample. They were invited to participate in the project because they were known to use computers or were suggested by a peer or principal. They are each, in their own way, successful teachers and do present a sufficiently varied group to avoid any suggestion that there is a preferred stereotype of the computer-using teacher. They were expected to present acceptable alternative role models for users of the IMM materials.

5.2.2.2 Analysis of the interviews

Responses to individual questions were divided according to the ideas expressed with each segment expressing one broad idea, perhaps with examples or other associated material. Each segment was identified according to the teacher, the question number and position of the segment within the response. Thus the third portion of Carla's response to question six would be identified as Carla 6.3.

Analysis of the transcribed interviews using the constant comparative method as described in the previous chapter resulted in six broad categories into which the comments of the teachers could be sorted. No doubt different categories could be proposed, and it is not suggested that the set proposed here is necessarily more correct than any other. However, it does serve to identify some significant elements, both common and diverse, in the responses. The final set of six categories is listed in Table 5.4 together with brief descriptions used as a guide in the analysis.

Table 5.4: Descriptions of major categories from interview analysis

Category	Description
Purpose	Statements which offer explanations of the decision to use computers in teaching
Development	Statements describing how a teacher has developed knowledge and skills with computers and/or obtains support for ongoing use of computers
Method	Statements that comment on practical aspects of working with computers in classrooms
Impact	Statements about the ways in which using computers has affected the teacher or children
Issues	Statements about problems or challenges associated with using computers for teaching
Internet	Statements which offer a view of the Internet and its significance for education

The distribution of statements attributed to the major categories is shown in Table 5.5. Each category was further divided into sub-categories. For simplicity, the data for each category will be presented separately. In each instance the sub-categories and their descriptions will be listed in a table followed by a second table summarising the frequencies of statements in each category and some examples which highlight key features of the data.

Table 5.5: Distribution of statements by category and teacher

Category	Carla	Julie	Karen	Ken	Matt	Neil	Robyn	Total
Purpose	3	2	3	3	4	5	2	22
Development	4	13	7	6	5	5	12	52
Method	7	7	1	3	3	4	4	29
Impact	3	7	7	4	6	4	8	39
Issues	3	4	4	3	3	3	13	33
Internet	1	2	1	1	2	2	3	12
Total	**21**	**35**	**23**	**20**	**23**	**23**	**42**	**187**

5.2.2.3 Purpose

Statements of *purpose* related to the teachers' views about why computers should be integrated into teaching. Question 2 was directed specifically at this issue but analysis revealed additional statements about purpose embedded in responses to other questions. The sub-categories identified in the data are shown in Table 5.6.

Table 5.6: Descriptions of sub-categories of purpose

Sub-category	Description
Vocational	Knowledge of computers is important to future study or employment
Future society	Computers are an integral part of current and future society
Potential	Computers offer educational benefits for teacher and children

Table 5.7 presents the distribution of responses about *purpose* according to the sub-categories and the teachers making the statements.

Table 5.7: Distribution of statements coded as purpose

Sub-category	Carla	Julie	Karen	Ken	Matt	Neil	Robyn	Total
Vocational		1	2	2	1	3	1	10
Future society			1	1	1	2	1	6
Potential	3	1			2			6
Total	3	2	3	3	4	5	2	22

Almost 50% of the statements about purpose were categorised as *vocational*, that is, related to the importance of computers for future employment and all but one of the teachers made at least one statement in this category. Julie asserted that the word processing skills she would teach to her nine-year olds were "the same skills that they'll learn when they're in high school, when they want to write reports for university, or in the work force" (Julie 2.2) and Karen suggested that students "could use some of the things that they have done, for instance, if they were looking for a job" (Karen 6.2) although she added a rider to indicate that looking for a job is an unlikely eventuality at primary school age.

Other statements categorised as *vocational* included the idea that the computer is a "tool that kids will need to know how to use" (Ken 2.2) and that using the computer "will give kids skills that they can use outside the classroom" (Matt 2.3). These statements do not explicitly mention work but are still strongly focused on the use of computers for tasks not directly related to classroom learning. Neil's focus on keyboarding skills was because "that's what's going to be used later in life" (Neil 6.1).

The statements categorised as *future society* were looking beyond the immediate educational applications for reasons to use computers but were less specific in their targets. Neil suggested that "technology is a thing of the future. Kids need to have an idea of basic use of computers because they're going to be what everybody's going to be using in the future" (Neil 2.1). In some respects statements like this one and others in this category appear to be almost fatalistic. Ken "chose to use technology in the classroom because it's available and, if we don't we're certainly behind the eight ball and it's just the way of the future" (Ken 2.1).

Most of the statements coded in the *potential* category were directed towards undefined benefits of computer use. Carla chose to use computers because they provide "such wide scope for the children" (Carla 2.1) and "they will have a sense of control over the technology - they can use it for what they want" (Carla 6.1). Julie chose to use technology "because it was something different" and she wanted "to see how it can be used; what the potential is" (Julie 2.1). The only cogent statements about specifically educational benefits associated with computers came from Matt who suggested that technology is "a way of enhancing the curriculum" and "can be a support base for all the other bits and pieces you do in the classroom" (Matt 2.1). He added that it "keeps the kids interested and it also gives you the opportunity to work with those kids that are having some troubles in class" (Matt 2.4).

Overall, fewer than a third of the fragments coded as *purpose* referred to the educational potential of computers. Most portrayed the use of computers in relation to preparation for future employment or to the impact of technology on present and future society. Despite this, as will be evident from fragments coded in other categories, these teachers were strongly committed to a variety of educational applications of computers. It may be that the statements relating computers to work and the future of society reflect earlier policy directions or messages appropriated from the media.

5.2.2.4 Development

The category denoted by *development* was used to collect statements that related to any reference to learning how to use computers or receiving support for computer use. Questions 1 and 5 asked specifically about relevant issues but relevant statements were found among responses to many of the other questions. This category had the greatest number of sub-categories associated with it. These are listed in Table 5.8.

Table 5.8: Descriptions of sub-categories of development

Sub-category	Description
Pre-service	Mention of courses taken prior to teacher qualification
Inservice	Mention of attendance at seminars and conferences
Reading	Mention of learning by reading
Experience	Mention of learning through personal experience
Networking	Mention of learning from professional colleagues

Sub-category	**Description**
Confidence level	Mention of confidence or fear in relation to computers
Teacher first	Mention that teachers learn about computers before children
Learning from children	Mention that teachers might learn about computers from children

Table 5.9 presents the distribution of responses about *development* according to the sub-categories and the teachers making the statements. This category is the most numerous, accounting for 28% of the total statements.

Table 5.9: Distribution of statements coded as development

Sub-category	**Carla**	**Julie**	**Karen**	**Ken**	**Matt**	**Neil**	**Robyn**	**Total**
Pre-service	1				1		1	3
Inservice		1	1		2	2	1	7
Reading	1	2		1			1	5
Experience	1	3	2	2	1	1	2	12
Networking		3	3	2	1	1	5	15
Confidence		2		1			1	4
Teacher first	1		2			1		4
Learn from children			1				1	2
Total	4	11	9	6	5	5	12	52

Only three of the teachers mentioned their pre-service course in relation to their developing approaches to teaching with computers. Carla reported applying some ideas from "Theatre in Education" (Carla 5.2) and Matt observed that the educational approach to computer use had changed very substantially since his courses (Matt 1.1). Robyn graduated some years after Matt and found that an option course she studied was helpful "because it was specifically aimed at how to use computers in teaching" (Robyn 1.1).

Inservice courses offered as seminars (Neil 1.1; 1.4) or conferences (Julie 1.3) by employers (Karen 1.2; Matt 5.1) or professional associations (Robyn 1.3) appear to have been more useful for these teachers than their pre-service courses. Reading material from professional associations (Julie 1.1), the Internet and library (Carla 5.1), computer magazines (Ken 5.2) or even software boxes and catalogues (Robyn 1.5) is also a significant source of useful information.

The most mentioned source of development was the variety of activities categorised as *networking*. This category was used for statements that relate broadly to any development occurring through contact with people including colleagues, local support staff, or members of Internet communities. There are formal avenues for support from central support agencies operated within schools (Neil 5.1) or school authorities (Karen 5.1) and with commercial suppliers (Karen 5.3). However, the majority of contacts are informal. At their simplest these statements referred to seeing other people use computers (Ken 1.1), talking to people who were using computers (Julie 1.2; 5.2) or using electronic mail for contact (Julie 5.3). Ken described the exchange of ideas thus: "I talk to other people. I steal ideas from other people and they steal ideas from me" (Ken 5.1). Although Ken referred to it as "stealing", he seemed to regard the exchange of ideas as a cooperative and mutually beneficial process although it probably does not often include explicit acknowledgment of sources. Robyn referred to the need to build up a network of friends for mutual support. She commented that the "increased interaction with other teachers is very beneficial" (Robyn 8.3) and described the use of the Internet as a source of support:

> I can go into support groups and publish questions and wait for answers. And there's so many people out there who are willing to help. There just seems to be an endless supply of help if you get stuck. There's always someone you can ask. (Robyn 5.6)

The other major source of teacher development was categorised as *experience*, and embraced an approach which was exemplified in Julie's comment that "it's a learn as you go sort of thing" (Julie 10.4). Ken described how he "played around with them on Christmas holiday, from school and just trial and error mostly" (Ken 1.2). Carla also referred to trial and error in the context of finding what would work in the classroom but linked that idea to drawing on her experience of teaching in other modes:

> I learned to use computers in my teaching by trial and error, by thinking about what would work, what had worked in traditional classrooms and basically by putting something to the kids and seeing what was going to happen. (Carla 1.1)

Julie described how she learned through picking up ideas from other teachers "and then just practice, just practice, just trying stuff" (Julie 1.4) and Robyn's advice to others was, similarly, "use your skills, have a go" (Robyn 10.3). Developing experience in this way, through experimentation or "play" is apt to require considerable time and access to computers. Ken commented that his progress accelerated when he bought his own computer "and then (he) suddenly learned very quickly" (Ken 1.2).

The process of learning by active experience extended into the classroom. Karen "just kept using it and teaching (her)self and using it with the children, and learning with them which was very good" (Karen 1.3). Julie "made it clear to the kids that we're learning together about the Internet and e-mail and everything. It's opening up a whole world for all of us" (Julie 10.5).

The remaining three sub-categories of *development* are more indicative of attitudes than of significant sources of information. Statements that were coded as *confidence* included references to teachers "not wanting to try using the computer in their classroom because they just don't think they have the knowledge" (Julie 10.3). Others noted that children are more inclined than adults to rapidly develop confidence in computer use (Julie 10.2; Ken 7.1).

In addition to learning with the children as noted above, some teachers referred to *learning from children*. Karen noted that "there were quite a few very good computer children and they taught (her) what (she) needed to know" (Karen 1.4). Robyn spoke in favour of using the skills that children bring:

> Don't expect to know everything. Or to always be the person who knows the most. There will always be children in the class who know more than you. Use them. Make them a part of the team. They'll love showing their skills off and you'll love learning from them. You build a really good relationship. (Robyn 10.2)

Another group of comments, coded as *teacher first*, expressed the idea that the teacher needed to develop the necessary skills before using the computer with the children. Julie described herself as "trying to overcome (her) own teething problems first and then try(ing) to help the kids as well" (Julie 5.5). Neil commented that the Internet was "another play toy that (he had) yet to develop the skills in" and that he did not expect to make much use of it until he had (Neil 9.2). The strongest statement in this category was from Carla who expressed a need to systematically prepare for using a computer with a class:

> If I had one computer coming into a normal classroom I would, firstly make sure I knew everything about that computer, so that I could be confident; I could leave a child with it and they could not do anything that would disturb me. So the first thing is I wouldn't let the kids on it until I had taken it home and played with it thoroughly. Number one. (Carla 11.1)

The frequency and variety of the fragments coded for *development* is a clear indication of the importance these teachers gave to ongoing professional development in respect of ICTs.

5.2.2.5 Method

Statements categorised as *method* related to the day to day practicalities of using computers for teaching. Questions 3 and 4 were most directly related to this category but analysis revealed relevant statements embedded in responses to other questions. The sub-categories identified in the data are shown in Table 5.10.

Table 5.10: Description of sub-categories of method

Sub-category	Description
Integration	Incorporating computers within the curriculum rather than as an add-in
Multiple activities	Using approaches in which the class includes several simultaneous activities
Independent learning	Children accepting a degree of responsibility for their own learning
Matching	Establishing an appropriate match between elements of the learning environment
Incremental	Planning for progressive development of computer skills
Structure	Establishing a highly structured learning environment

Table 5.11 presents the distribution of responses about *method* according to the sub-categories and the teachers making the statements.

Table 5.11: Distribution of statements coded as method

Sub-category	Carla	Julie	Karen	Ken	Matt	Neil	Robyn	Total
Integration		1			1	2	2	6
Multiple activities		3	1		1			5
Independent learning		2			1	1	1	5
Matching	2	1		2		1	1	7
Incremental	4			1				5
Structure	1							1
Total	7	7	1	3	3	4	4	29

Statements were categorised as *integration* if they conveyed the idea of learning *with* computers as opposed to learning *about* computers. Matt provided a succinct statement about the principles of curriculum integration of computers:

> You obviously need to plan that your technology is going to fit in with your existing curriculum. I don't think it's appropriate that you build your curriculum around technology, but that the technology fits in with the curriculum. So looking at what you need and want to teach and how technology can support you in that. Finding the programs, establishing your own program so that it includes the use of technology. (Matt 3.4)

Robyn expressed similar ideas and included an example:

> I feel that it's very important to start off with the relevance of what you're doing. It has to tie directly into what they're learning in the curriculum. I don't believe in learning computers just so that you learn how to use a computer. You should learn to use a computer so that you know how to do a specific task that you're doing that will further an objective in the classroom. So if we're doing for instance, initial sounds then they'll learn to use the program that gives them work with initial sounds. And then they'll learn to save their work if necessary, to get out of the program. So we learn the skills that we need. I use those factors; that's the first one. (Robyn 3.1)

Successful integration of computers across the curriculum depends upon access to appropriate resources and a degree of creativity. Neil commented that he found it difficult to integrate in mathematics although he had used the computer for remediation and extension work (Neil 7.1). Julie described how she had used her Travel Buddies project as the stimulus for work across several curriculum areas (Julie 6.3).

Making optimal use of limited computer resources frequently requires that activities using the computer proceed simultaneously with other activities in the classroom. The *multiple activities* sub-category was used for statements related to this idea. In planning for computer use, Julie "wanted something that (she) was going to be able to do that the kids were going to use the computer, but they weren't all needing a computer at once" (Julie 3.1). Karen "found that if (she) used group work, (she) could rotate groups and (she) always had someone then working on computers" (Karen 3.2). Managing multiple activities requires planning of the physical space as well as the activities. Matt noted that he had

> the computer set up in the classroom in such a way that (he could) monitor what the kids are doing. Other people might prefer to put them physically out of sight, so that one group of kids are not disturbing another. (Matt 4.2)

Successfully operating multiple simultaneous activities depends upon the capacity of children to work independently. Statements related to this concept were coded as *independent learning*. Julie expressed a need to plan activities that children could do with minimal supervision where she could "tell them something and they'd be able to go and do it" (Julie 3.2). Matt noted that expecting students to manage their own work was more realistic with older groups (Matt 3.3). Robyn described the type of independent activity that she preferred:

> Another management strategy is to always have open ended projects so that children, the brighter ones, the faster ones can always just do that little bit extra on their work. You don't ever want to have the children finish and that's it. Or go too far ahead of the rest of the class. So it's best to have open ended projects and they can work on it. (Robyn 4.4)

Matching was used to identify statements that mentioned the need to bring together appropriate combinations of children and/or resources. Robyn noted that "sometimes they work individually, some children work better that way, and sometimes I pair them" (Robyn 3.4). Julie described how she had

> two on the computer at a time, so that they can trouble shoot off each other because they don't know anything yet, or very little. Some of them do have computers at home so I've tried to match one of them up with someone who doesn't know as much. (Julie 4.1)

Ken also mentioned the need to consider children's "backgrounds in (computer) use, because some kids have got computers at home" (Ken 3.2). However, Carla, who works with children at different year levels, noted that she considered the "different age levels and skills" (Carla 3.3) and the "question of matching software with your grade" (Carla 11.2).

All but one of the statements assigned to the *incremental* sub-category were from Carla and related to her efforts to "build in little steps so that they experience success every lesson" (Carla 2.2). Ken expressed a wider view of progressive development in which as children "progress through the school they should be able to use more and more" (Ken 6.2) of particular programs.

The sole statement assigned to *structure* was Carla's description of her highly structured approach to managing the work of 30 children in a ten computer laboratory (Carla 4.1).

Many of the fragments placed in this category related to managing the use of ICTs, especially the complexity that arises in establishing appropriate matches among children, curriculum and computers. Despite the challenges these teachers managed to maintain a focus on the educational value of the activities rather than on using ICTs for their own sake or as a "filler" when students completed other activities.

5.2.2.6 Impact

Statements categorised as *impact* described ways in which using computers had affected teachers or children. Questions 6, 7 and 8 were most directly related to this category but analysis revealed relevant statements embedded in responses to other questions. The sub-categories identified in the data are shown in Table 5.12.

Table 5.12: Descriptions of sub-categories of impact

Sub-category	Description
Motivation	Teacher and/or student motivation is increased
Efficiency	More can be achieved with the same amount of time and effort
Work quality	Children produce better quality work
Growth - teacher	Evidence of professional growth of teachers
Growth - children	Evidence of personal growth in children

Table 5.13 presents the distribution of responses about *impact* according to the sub-categories and the teachers making the statements.

Table 5.13: Distribution of statements coded as impact

Sub-category	Carla	Julie	Karen	Ken	Matt	Neil	Robyn	Total
Motivation		7	1	2	1		3	14
Efficiency	1			2	2	3	2	10
Work quality			3				1	4
Growth - teacher	1		3		3	1	2	10
Growth - children	1							1
Total	3	7	7	4	6	4	8	39

The most commonly cited impact was enhanced *motivation* of teachers and children. Ken described how he reacted as he developed increasing skills once he had a home computer: "I kept coming to school and saying 'Look what I can do, look what I can do, look what I can do!' And it's just taken off from there" (Ken 1.4). His personal enthusiasm carried over into his teaching and apparently affected the children in his class:

> It's become important because it's become a hobby of mine and I'm trying to instil that enthusiasm in the kids and to this day I think I've done a reasonable job of that because I have a lot of keen kids who enjoy being on the computer in non-school time and doing school tasks in the school time. (Ken 8.2)

Robyn reported that working with computers "keeps (her) feeling fresh and excited about everything. As technology moves (she became) excited about what's happening and it definitely keeps (her) up and about" (Robyn 8.2). She also reported that it made the work of children "real and exciting because they can see that it's meaningful. It's going somewhere. They can publish it. Other people are interested in it, they can read it" (Robyn 9.2) and that children "definitely take more pride in what they're doing" (Robyn 7.2).

Children were motivated directly to work at the computer. Julie described how children were "running over to the computer and they want to type their stuff up on the computer and they're plodding away one key every minute" (Julie 7.1). However, motivation derived from computer related projects sometimes extended to more standard forms of work:

> Andrew yesterday was writing this report and he didn't want to do it and I said this has to go to the class in New York and his face lit up and he was saying "Oh, it has to be my best hand writing and my best spelling" and then he had his best handwriting and everything and he was so proud of it then because it was going to someone else and he had a real audience. And I think that was the main thing. It was the motivation that the kids actually want to learn the stuff. (Julie 6.2)

Statements categorised as *efficiency* referred to achieving more with the same effort. Ken regarded using computers as "just a plus/plus situation" (Ken 2.3) which allowed him to produce better teaching resources with less effort. He "used to spend a lot of weekends making charts" but the computer allowed him to "go to the computer at home, whip up a very professional chart, blow it up to A3 and it's done" (Ken 8.1). Neil found that

> it's far easier to go to a CD-ROM than it is to go to a library. You really have your library in the room and it's easier to access that library in the room situation than to have to physically withdraw the kids and go to the library and then search through a mountain of books. It's a lot easier that way. (Neil 8.3)

For Robyn, it was very important that using computers "reinforces and consolidates the things that we're doing in the classroom" (Robyn 6.1). However, she found that it also extended her capacity to reach some students:

> Also for some children the conventional methods of teaching just don't quite work and this is another way of reaching children. By broadening the presentation of the ideas that I'm trying to put across, I can get children that normally won't click onto the idea. So I feel that's really important. (Robyn 6.2)

Matt expressed similar thoughts about catering to difference by "teaching students in the best way possible and allowing them to learn from a variety of media, and learn in the best way that they can, how ever they can" (Matt 6.2). He suggested that by allowing students to

> learn from a broader base they are picking up other skills other than pure curriculum skills of reading, writing and mathematics and those sorts of things. There are other skills that come into it. Technology skills, typing skills, looking at design features, those types of things. (Matt 7.1)

Where the statements referred to changes in the quality of work rather than the quantity they were coded as *work quality*. Robyn described how she expected more from children using computers because "I feel that they should have higher presentation skills. They should be giving me more complex ideas" (Robyn 6.3). Karen also referred to presentation skills and the impact that had on the confidence of students (Karen 6.1; 6.3). She found that it offered particular benefits to "children whose work isn't very neat, whose handwriting isn't very good, they come up with a finished product that they are really proud of and theirs can be just as good as everyone else's then" (Karen 7.1).

Several of the teachers described an impact on their professional *growth*. Neil spoke of his increased awareness of computer-based resources (Neil 8.1). Karen commented that "you do have to change your idea of the way you taught traditionally" (Karen 3.1) and described "using computers now instead of just the traditional mode of teaching because I like to use both methods, traditional and the new methods" (Karen 2.1). Carla could no longer contemplate teaching without a computer: "I know that if I ever went back to teaching in a classroom again, I couldn't live without a computer. I don't think there's a subject that I can teach, that I would want to teach without a computer" (Carla 8.1).

Matt noted that using computers had allowed him "to learn a lot of bits and pieces about teaching" and to extend himself in his role as a teacher (Matt 9.2). He linked this to the motivation he gained from the challenge of working with computers and the effort involved in that:

> It's been a challenge. It challenges me to think a little bit more broadly about what I can do in the classroom. But it's also a lot of fun too. It requires time. You've got to put time and effort in so that you are well prepared and at least one or two steps ahead of where the kids are going to be at. But it allows you to put some stuff into the curriculum that really enthuses the kids and it keeps me enthused as well. And that's good. (Matt 8.1)

Robyn also described how using computers had taken her away from "chalk and talk" to a broader approach to teaching (Robyn 8.1) but the major impact for her was an enhanced sense of collegiality in her professional life:

> Also it really helps my interaction with other teachers. I feel like I've enjoyed meeting and getting to know many more teachers than I probably, ordinarily, would have because teachers who are interested in technology tend to talk about it more. They get excited about what they're doing and they start asking things like "Have you tried this?" or "Have you tried that?" Or alternately, they can get excited in other ways and say "I've got a problem. Have you ever had this happen to you? Or that happen to you?" So there's a lot more interaction, a lot more talking and teachers tend to build up a network of friends around the area. I really feel that just the increased interaction with other teachers is very beneficial to me. (Robyn 8.3)

Children also showed evidence of *growth*. Carla spoke of their increase in confidence, of having a "far greater sense of they know what they are going to do" and being able to organise their work (Carla 7.1).

According to these teachers the strongest impact of ICTs appears to be on motivation for both learners and teachers. They also recognised benefits for the efficient use of time and for their personal and professional growth.

5.2.2.7 Issues

Statements categorised as *issues* identified problems or challenges associated with using computers in teaching. Questions 3 and 4 were most directly related to this category but analysis revealed relevant statements embedded in responses to other questions. The sub-categories identified in the data are shown in Table 5.14.

Table 5.14: Descriptions of sub-categories of issues

Sub-category	Description
Resources	Obtaining and managing physical resources including hardware, software and space
Time	Managing time within and between classes
Technical	Dealing with technical issues associated with using computers
Behaviour	Dealing with behaviours that result from using computers in class

Table 5.15 presents the distribution of responses about *issues* according to the sub-categories and the teachers making the statements.

Table 5.15: Distribution of statements coded as issues

Sub-category	Carla	Julie	Karen	Ken	Matt	Neil	Robyn	Total
Resources	1	1	3	2	1	1	4	13
Time	1	1	1	1	2	2	5	13
Technical	1	1					3	5
Behaviour		1					1	2
Total	3	4	4	3	3	3	13	33

Computers bring with them a variety of challenges of which perhaps the most obvious is *resources*. Carla listed "time, space, the amount of money I've got to buy the computer software that I want to buy" (Carla 3.1). Time was categorised separately but the remaining resource issues mainly revolved around the availability and placement of computers. Matt summarised the key issues:

> When you're using technology in the classroom you need to plan a variety of things. Not the least of which, where the computers are going to end up in the classroom. How many computers you're going to use in the classroom. Whether they're actually going to be in the classroom or in a lab somewhere else in the school. At this school we have them distributed throughout the classrooms. So in this classroom there's two computers. We need to consider

> where they're going to be. That's probably the first step. Just managing the placement. (Matt 3.1)

Julie described some of the factors she considered in placing the computer in her classroom:

> It had to be near the power point and not next to the heater, because that's where I had it first. And it couldn't be near a window ... yeah so there was only one place left to put it. And not near the door. (Julie 3a.1)

Karen observed that "computers do take up quite a bit of room", described alternatives for different classroom arrangements and concluded that "you do have to rethink the way you're going to set out your classroom" (Karen 4.1).

None of these teachers worked in a laboratory with sufficient computers for an entire class. As a consequence they had to consider "the amount of computers that we've got or the number of computers, the number of children" (Ken 3.1). Neil commented that although there were only five computers shared in his double teaching space there were often ten children working there and "another 15 or 20 kids … that (he had) to cater for as well" (Neil 3.2). Similar challenges emerged when classes had more than two children per computer, necessitating alternative activities for the remaining children (Robyn 3.3).

Challenges associated with *time* were related to managing the use of small numbers of computers with full classes. Such challenges emerged both within a single class and in managing resources across multiple classes. Karen observed that "children will need time to use the computers and do the work they have to" (Karen 8.2) and Ken referred to managing the "amount of time you can afford to have somebody, one person at one keyboard doing a particular task" (Ken 4.2). Neil identified the need to find time to work directly with children at the computer (Neil 3.1) and suggested the use of parent volunteers to supervise other class activities to free the teacher to work with children at the computers (Neil 4.1). Robyn also suggested the use of parents but with suitable training so that they could assist the children (Robyn 4.3).

Robyn used a personal system of rotation to work around the room and ensure that "no child sits in the corner with their hand up for half and hour" (Robyn (4.2). Matt used a timetable to identify periods when children should not use the computer such as during whole class teaching segments (Matt 3.2). This was one of the challenges that Julie was working with as a beginning teacher:

> I'm finding it hard at the moment when to decide when its OK for them to be on the computer and not being in the lesson and when they have to be in the lesson. Like sometimes I might send them over and a few seconds later I realise that they needed to hear that. I'll either ask them to stop what they're doing and just listen or to come back to their desk and to participate in the activity. (Julie 8.2)

Carla's role in providing computer lessons to multiple classes caused her to think about "how I'm going to work in with other teachers and grab some time from them so I can teach their students" (Carla 3.2). Robyn identified planning laboratory access as an issue to be taken "into consideration, when it's available, when I can go in, especially if I'm doing a unit of work and I need it" (Robyn (3.2). She described how the laboratory timetable had sufficient free time to allow some flexibility in access times by different classes (Robyn 14.3) and how good communication among staff in forward planning for laboratory use (Robyn 14.5).

Technical problems received relatively few mentions. Carla alluded to experiencing high levels of frustration when first using computers (Carla 10.2) and Julie referred to initial difficulties in working with a different operating system (Julie 5.4). Robyn suggested that many problems could be minimised by anticipation and preparation:

> Also anticipating problems is very important. Computer classrooms seem to be built around problem solving and if you anticipate, firstly by testing what you're going to do, make sure it works. And then have spare backup discs or programs or ideas so that you know if the program won't open or the disk crashes then there's always some way around it, without being flustered. So you learn to be flexible and problem solve as you go. (Robyn 4.5)

Two of the teachers identified noise as a *behaviour* issue. Julie mentioned the need to monitor noise levels to ensure that children at the computer did not distract the rest of the class (Julie 4.2). Robyn saw increased noise levels as an inevitable and mainly positive aspect of working with computers:

> Definitely the noise factor. If you're not used to using computers, the first thing you notice is that children are a lot noisier. But if you stop, and listen to them you'll find, or I have found, that the majority of noise that's coming from them is productive talk. Children get on to computers and they talk about what they're doing. They share ideas; they get excited with what they're doing. So noise is very much a factor. And it's not something that I cut out, it's something that I control, I just keep the noise down but still encourage them to talk. (Robyn 4.1)

Lack of time and resources and the consequent need to manage them effectively were the major issues identified by the teachers. Among them they demonstrated a variety of solutions to making the most of their time and resources.

5.2.2.8 Internet

Statements categorised as *internet* referred to teachers' use of the internet with classes. Question 9 was most directly related to this category. The sub-categories identified in the data are shown in Table 5.16.

Table 5.16: Descriptions of sub-categories of internet

Sub-category	Description
Communication	Views of the Internet as a means of communication for various purposes including exchange of information
Information	Views of the Internet as a source of information independent of communication with other users

Table 5.17 presents the distribution of responses about *internet* according to the sub-categories and the teachers making the statements.

Table 5.17: Distribution of statements coded as internet

Sub-category	Carla	Julie	Karen	Ken	Matt	Neil	Robyn	Total
Communication		1	1	1	1	1	3	8
Information	1	1			1	1		4
Total	1	2	1	1	2	2	3	12

Most of the statements about the *internet* referred to it primarily as a means of *communication*. Several of the teachers had used e-mail to establish contact between their class and children elsewhere (Karen 9.2; Ken 9.1; Matt 9.4). Although the immediate application was communication, the outcome of that communication was often associated with obtaining information. Thus, Robyn suggested that children could "contact other people, have mentors through the Internet. E-mail for information about different topics and subjects" (Robyn 9.3). She referred to online projects (Robyn 9.4) and compared the Internet to a global village:

> It's like a global village. The children get to know other children around the world through E-mail or through live chats. And it doesn't become a case of "us and them" any more. They relate to these children and understand that they're just children like themselves. (Robyn 9.1).

Julie described how she had explained the Internet to her class as a community:

> I drew a model the other day on the board before we got the computer, trying to show them what the Internet was about and explaining to them that it's a big community and I think that's the thing that I'm trying to get across to them, is that it's not a source of information that it's a community and that they're being part of the community. (Julie 9.2)

The alternative view of the Internet is as primarily a source of *information*. Neil had referred to his son having pen friends on the Internet (Neil 9.4) but also noted its value as a source of information, citing the NASA sites as an example (Neil 9.5). Carla tended to view the Internet primarily as an information source and suggested that "encyclopaedias are now out of date" (Carla 9.1). Matt described how, in addition to communication, the Internet had allowed him to provide children with a "taste of the world" although the existence of "good and bad points" on the Internet meant that "we need to manage the bad points a little bit" (Matt 9.3).

5.3 Prototype trial

As described in Chapter 3, two questionnaires were administered in association with the prototype trial. The multi-instrument questionnaire (see Appendix C), which included the Microcomputer Utilization in Teaching Efficacy Beliefs Instrument (MUTEBI), Attitudes towards Computer Technologies (ACT), Self-efficacy for Computer Technologies (SCT) and other scales, was administered prior to the trial. The user evaluation questionnaire was administered after the trial.

5.3.1 Multi-instrument questionnaire

5.3.1.1 The respondents

Participants in the prototype trial were students in the final semester of the four year Bachelor of Education (Primary) program. As described in Chapter 3, the software trial was conducted in the final week of classes, immediately prior to examinations that were to be followed by a six week period of teaching experience in multi-age classrooms. By arrangement with the relevant lecturer, the author attended a lecture session at the beginning of the week to explain the operation of the software trial. The questionnaire was administered during that session.

A total of 31 students (25 females and 6 males) completed the questionnaire. Twenty nine respondents provided their ages. Most reported their ages as 20 years (6 students), 21 years (12) or 22 years (6). The remainder recorded ages of 23 (2), 25 (2) and 28 (1). The clustering of ages around 21 years suggested that most respondents had entered the degree program directly from secondary school and that only a small number were mature age students.

As an indication of relative familiarity with computers, respondents were asked to select a category which represented the number of hours they spent working with a computer in a typical week. Of the 31 responses, 4 selected the less than one hour per week category, 13 selected 1 to 5 hours, 11 selected 6 to 10 hours and the remaining 3 reported using a computer for more than 10 hours per week.

5.3.1.2 Scale reliabilities and results

Reliability values (Cronbach's alpha) were computed for each of the scales. For each scale, student scores were computed as the mean of the item scores for each student in order to facilitate comparisons among scales. Table 5.18 shows the alpha reliability values, means and standard deviations of the results obtained for each scale together with the maximum score possible on the scale as determined by the number of points on the Likert scale.

Table 5.18: Reliability (alpha), mean and SD of scores (N = 31)

Instrument	Sub-scale	Reliability (alpha)	Scale maximum	Mean	SD
MUTEBI	Outcome expectancy (OE)	.77	5	3.61	.56
	Self-efficacy (SE)	.85	5	3.24	.57
ACT	Comfort/Anxiety	.85	4	2.79	.54
	Usefulness	.74	4	3.42	.30
SCT	E-mail	.98	4	2.31	1.12
	Internet	.95	4	2.29	1.02
	Word processing	.83	4	3.64	.45
	Operating system	.84	4	3.08	.67
	Spreadsheet	.92	4	3.09	.71
	Database	.94	4	2.96	.79
	CD-ROM	.92	4	2.62	.80
	SCT composite	.97	4	2.90	.61
PCI		.62	5	2.48	.43
Teacher Efficacy	External	.81	6	2.71	.65
	Internal	.82	6	4.37	.58
Innovativeness		.71	7	5.02	.64

The reliability estimates were compared with those reported from the sources of the scales as identified in Chapter 3. For the SE scale of the MUTEBI, the reliability found in this study (.85) was slightly lower than the value of .91 reported previously (Enochs et al., 1993). The reliability found for OE (.77) was very similar to the value of .78 reported by Enochs et al. The ACT scales (Comfort/Anxiety and Usefulness) returned reliabilities (.85 and .74) slightly lower and higher, respectively, than those reported for a previous study (.90 and .71) conducted using the ACT and SCT with students in the first year of the same education degree program at USQ (Albion, in press). The reliabilities for the various SCT scales and the SCT composite were generally comparable, except for the word processing and operating systems scales (.83 and .84) which were somewhat lower than the previously reported values (.95 and .91). There is no apparent explanation for this difference. The value of .62 returned for the PCI scale is somewhat lower than the previously reported value of .75 (Enochs et al., 1995). This difference may be related to the use of the shortened (10 items rather than 20) version in this study. Similarly, the reliability for the Innovativeness scale (.71) was lower than the value of .94 reported previously (Hurt et al., 1977) but still acceptable. Reliabilities for the Teacher Efficacy scales were not reported previously but the values of .81 and .82 are acceptable. All of the scales selected for use in the study appear to be acceptably reliable.

The means obtained on the scales were also compared with those reported for previous studies where relevant data were available. Previous studies using the PCI (Enochs et al., 1995) and Teacher Efficacy scales (Guskey & Passaro, 1994) did not report means. Hence no comparisons were possible for these scales. At 2.48, which is slightly less than the mid-point score of 3.00, the mean score for PCI indicates that these prospective teachers exhibit a slight preference for non-custodial approaches to classroom management. The mean scores on the teacher efficacy scales suggest that, on balance, they believe more strongly in their capacity for personal influence in teaching (internal = 4.37) than in the influence of factors beyond the direct control of a teacher (external = 2.71).

In a study of 14 US teachers engaged in a staff development project (Borchers et al., 1992), measurements were obtained using the MUTEBI at three different times. Those data were reported as scale totals, but knowledge of the number of items in each scale permitted calculation of means for comparison. That study recorded pretest and posttest means of 3.64 and 3.69 for OE and 3.12 and 3.79 for SE. These values are comparable to the means obtained in this study of 3.61 for OE and 3.24 for SE. Like the teachers in the US study, these prospective teachers believe that teachers are able to influence pupils' ability to use the computer effectively (OE = 3.61) but are less confident in their own ability to use the computer effectively for teaching (SE = 3.24). If there is any significance in the mean SE for this group being higher than the pretest value for the US teachers, the explanation may lie in the general increase in familiarity with computers during the years since the earlier study.

A study involving 170 US elementary teachers (Marcinkiewicz, 1994a) reported values of Innovativeness equivalent to a mean score of 5.18 which is not significantly different from the value of 5.02 found in the present study. That mean value is slightly above the mid-point (4.0) of the scale, indicating a generally positive disposition towards change.

Scores for the ACT and SCT scales indicate that the respondents are comfortable about computers and believe strongly in their usefulness for their future work. They are confident about their ability to use a variety of common software but are noticeably less confident about their use of e-mail and the Internet. The ACT and SCT scores were compared with the posttest scores reported for 89 students in a previous study conducted at USQ (Albion, in press). The only significant differences were for Usefulness ($t = 3.11$, $df = 117$, $p = .002$) and word processing ($t = 2.45$, $df = 115$, $p = .016$). In each case the final year students in the present study returned higher scores, indicating stronger beliefs in the future usefulness of computers and greater confidence in their ability to use a word processor. A higher score for usefulness might conceivably be related to the persuasive effects of experiences encountered in the university course. Confidence for word processing is most likely the result of experience gained through students' frequent use of word processing for assignment preparation.

Overall, these pre-service teachers appear to be favourably disposed towards the use of computers for teaching. They believe in the value of computers for teaching and in the capacity of teachers to influence pupils' use of computers for learning. They are generally comfortable with computers and confident in the use of common applications software. They believe in their capacity as teachers to influence events in the classroom, are positively disposed to change, and tend to favour student-centred classroom styles that are compatible with those typical of computer-using teachers. However, the mean score for SE is just above the mid-point on the scale, suggesting that there is scope to increase their confidence in their capacity to teach with computers.

5.3.1.3 Relationships among the variables

Because the overall study was intended to investigate the possible effects of IMM-PBL on self-efficacy for teaching with computers as measured by the SE scale of the MUTEBI, it was important to know which of the other variables might influence SE. Hence correlations among the variables were investigated.

Pearson product moment correlation coefficients were computed for pairs of measures from the questionnaire. As described previously (Albion, in press), scores on the sub-scales of the SCT were combined to form a composite measure of self-efficacy for computer use and that measure rather than the more specific sub-scales was used in the calculation of correlation coefficients which are shown in Table 5.19.

Table 5.19: Correlation coefficients for pairs of scales (N = 31)

	Comfort	Usef.	SCT	PCI	OE	SE	Ext.	Int.
Usefulness	.52**							
SCT	.59**	.36*						
PCI	-.03	-.28	-.10					
OE	.56**	.54**	.49**	.06				
SE	.50**	.33	.75***	-.07	.44*			
External	-.18	-.21	-.29	.38*	-.20	-.41*		
Internal	.01	.15	.21	-.28	.31	-.01	-.22	
Innovativeness	.42*	.30	.10	-.30	.20	.00	-.04	.27

* $p < .05$ ** $p < .01$ *** $p < .001$ (2-tailed)

The highest correlation was between the self-efficacy (SE) sub-scale of the MUTEBI and SCT, implying that stronger beliefs in personal capacity to work with computers are associated with self-efficacy for teaching with computers. SE was also significantly correlated with the comfort/anxiety sub-scale of the ACT, confirming that students who felt comfortable with computers felt more positive about teaching with them.

Outcome expectancy (OE) on the MUTEBI corresponds to student teachers' beliefs that, through good teaching, they could increase the computer competence of pupils in their class. OE was significantly correlated with both sub-scales (comfort/anxiety and usefulness) of the ACT and with the composite SCT score. The implication is that graduates who have strongly positive attitudes towards computers and confidence in their ability to use them are more likely to believe that they can transmit those qualities to their pupils.

The remaining high correlations are between the two sub-scales of the ACT and between the comfort/anxiety sub-scale of the ACT and the SCT. These relationships have been reported previously (Albion, in press). It is hardly surprising that beliefs in the usefulness of computers, which would probably influence patterns of use, should be correlated with feelings of comfort with the technology. It is equally understandable that comfort with computers should be related to confidence in their use as measured by the SCT.

Contrary to expectations based on previously reported results (Enochs et al., 1995; Marcinkiewicz, 1994a), neither Innovativeness nor PCI was significantly correlated with either sub-scale of the MUTEBI. A significant correlation was found between Innovativeness and the comfort/anxiety sub-scale of the ACT. This might be explained in terms of comfort with new technologies being indicative of preparedness to adopt new approaches. The significant correlation between PCI and the external sub-scale of the Teacher Self-Efficacy instrument may indicate an association between a custodial orientation towards classroom management and a belief in the power of influences beyond the direct control of the teacher.

The factors most strongly correlated with the SE sub-scale of the MUTEBI are comfort with computers and self-efficacy for computer use. These are among the factors that might be influenced by students' working with a multimedia package that presents examples of effective use of technology in teaching, together with opportunities to rehearse relevant patterns of thought. Based on these results there was reason to anticipate that the IMM-PBL materials might be effective in increasing self-efficacy for teaching with computers.

5.3.2 User evaluation questionnaire

The prototype trial had been planned to involve all of the students in the final year of the Bachelor of Education (Primary). These students (N = 31) were described in the previous section. As described in Chapter 3, technical problems in the preparation of the prototype delayed its availability and only fifteen students (12 females and 3 males) were able to work with the prototype for approximately two hours each. They completed the evaluation questionnaire at the end of their session with the materials.

Table 5.20 summarises the results obtained for the 20 Likert scale items on the questionnaire. Items for which the numbers are underlined were negatively phrased and have been reverse scored to assist in the interpretation of ratings. The table shows the number of responses recorded for each point on the scale together with median ratings.

Table 5.20: User evaluation data for the prototype trial (N= 15)

No.	Item	SD 1	D 2	N 3	A 4	SA 5	Median
1	I was enthusiastic about using the multimedia package as a part of my study	1	1	3	5	5	4.0
<u>2</u>	The problem presented in this multimedia package was <u>NOT</u> closely related to the everyday experience of teaching	7	8				4.0
3	The problem presented in this multimedia package was relevant to my future work as a teacher				6	9	5.0
<u>4</u>	Using this multimedia package did <u>NOT</u> help to increase my confidence for making professional decisions	2	9	4			4.0
5	Using this multimedia package helped to improve my knowledge of classroom management			3	12		4.0
<u>6</u>	Working with this multimedia package did <u>NOT</u> help me to prepare better for using technology in my classroom	5	9	1			4.0
7	Using this multimedia package helped to improve my understanding of integrating technology into teaching			3	8	4	4.0

No.	Item	SD 1	D 2	N 3	A 4	SA 5	Median
8	Using this multimedia package increased my confidence for dealing with related issues in my own classroom			4	11		4.0
9	In my opinion this type of multimedia package is a very effective learning tool				9	6	4.0
10	The quality of the sound on this multimedia package is very good				8	7	4.0
11	The visual quality of the video presented on this multimedia package is very good				8	7	4.0
12	The operating instructions included on the multimedia package were sufficient to allow me to use it effectively	1	6	3	5		3.0
13	The textual materials on the multimedia package were of high quality			2	10	3	4.0
14	There was NOT adequate feedback for the tasks on the multimedia package	1	5	7	1	2	3.0
15	The problem on the multimedia package progressed in a logical fashion		3		12		4.0
16	Navigation through the multimedia package was NOT difficult		5	3	4	3	3.0
17	Sufficient time was allowed to work through the tasks		2	1	10	2	4.0
18	The resources on the multimedia package were difficult to access	1	9	3	2		4.0
19	Colours used in the multimedia package interface were suitable				11	4	4.0
20	There were NO difficulties in operating the software	2	9	1	3		2.0

User response to the materials was generally positive. Students reacted very favourably to the presentation of the materials (items 10, 11, 13 and 19) and perceived them as highly relevant to their professional preparation (items 2, 3, 4, 6 and 7).

Item 20 was the only item for which the median score (2.0) indicated an overall negative reaction to the IMM-PBL materials. Three items (12, 14 and 16) had median scores of 3.0. Items 12 and 20 referred to operating instructions and operational difficulties. Because of delays in preparation of the prototype and the limited availability of the students, the trial was conducted with a version in which the interface was incomplete and only very limited operating instructions were included. The navigational issues implied by the response to item 16 were mainly attributable to the use of the "to do list" as described in Chapter 4. Not all of the sample responses to tasks had been incorporated in the prototype and the response to item 14 was consistent with this.

Overall, these results provided confirmation of the broad appeal of the IMM-PBL materials to pre-service teachers and served to identify elements that required attention in the subsequent design phase.

Items 21 to 27 on the questionnaire asked users to indicate how they thought a change in the amount of various elements might improve the overall package. Table 5.21 summarises the responses to those items.

Table 5.21: Desirability of content elements in the prototype (N = 15)

No.	Resource type	Much less 1	2	3	Much more 4	5	Nil	Median
21	Text resources	1		11	1	1	1	3.0
22	Audio (without video)	1	1	6	6	1		3.0
23	Video			6	5	4		4.0
24	Photographs			7	5	3		4.0
25	Drawings			3	9	2	1	4.0
26	Theoretical background		2	5	4	3	1	3.5
27	Sample solutions			2	7	6		4.0

Overall, respondents saw that the addition of each of the different forms of content could improve the package, although clearly some elements had stronger appeal. The strongest response was for sample solutions, reinforcing the response to item 14, which was discussed above. Most appeared to agree that the quantity of text was about right and favoured the more visual components, nominating drawings, video and photographs in that order.

Item 36 in the questionnaire asked users to mark those aspects of teaching and planning for which working with the prototype had enabled them to gain some insight. Table 5.22 summarises the responses for this item as raw frequencies and as the percentage of respondents who selected each aspect.

Table 5.22: Nomination of aspects of teaching in the prototype (N=15)

Aspect of teaching	f	%	Aspect of teaching	f	%
teachers' self organisation	12	80	physical layout of a classroom	14	93
classroom management	10	67	room arrangements	13	87
travel patterns	4	26	arrangements of desks	12	80
use of other personnel	9	60	teaching strategies	3	20
teachers' knowledge of technology	12	80	selection of appropriate strategies	4	26
sequencing of activities	1	7	teaching skills	5	33
integrating content	7	47	managing small groups	6	40
dealing with diverse groups of children	5	33	checking for understanding	0	0
assessing student work	1	7			

The strong responses for technology, organisation, classroom management and physical arrangements within classrooms reflect the content of the tasks presented in the prototype and confirm that users thought they had learned something by using the materials.

The remaining items on the questionnaire were open-ended questions. Most responses were positive about the IMM-PBL materials, their functioning and the content they presented. Nine of thirteen responses nominated the video interviews with teachers as their favourite part and this was reflected in other comments about the value of access to other teachers' ideas and seeing examples of computer use in classrooms. The task involving arrangement of furniture in a classroom was also nominated as a favourite and several respondents commented on the value of such practical experience in areas they had not encountered previously.

Most of the responses to a question about the weak points in the package referred to navigational or technical issues, reinforcing the responses described previously. Users experienced some confusion about how to work through the materials. They suggested the addition of clearer instructions and integrated help. Some mentioned specific technical problems such as graphics that persisted on a screen when a user moved to the next section of the materials.

Data from the user evaluation questionnaire revealed that user response to both the content and presentation of the IMM-PBL materials prototype was generally positive. Useful insights into user preferences for both content and modes of operation were obtained. These were applied in the design review described in Chapter 3 and influenced changes that were made in the development of the beta version.

5.4 Beta evaluation

Ten responses were received from the fifteen persons invited to participate in the beta evaluation. The time taken by individual evaluators to return their forms varied from a few days to several weeks. Followup requests were sent to those who had not responded within three weeks of the distribution of the CD-ROMs and questionnaires The reasons for the delays varied but were mostly related to the other commitments of the evaluators who were all volunteers undertaking the evaluation on their own time. Table 5.23 summarises some key data about the respondents to the beta evaluation questionnaire.

Table 5.23: Characteristics of the beta evaluators

ID	Level of experience			Computing skill	Operating system	Browser
	Software design	Instructional design	Teaching			
1	Nil	Nil	15 y	Competent	MacOS 8.0	Netscape 4
2	Nil	Nil	6 y	High	Windows 95	Netscape 4
3	Nil	30 y	43 y	Basic	MacOS 8.1	Netscape 4
4	Nil	Nil	15 y	Fair	Windows 98	Netscape 4
5	20 y	22 y	22 y	High	Windows 95	Netscape
6	Nil	Nil	Nil	Above average	Windows 95	Netscape & MSIE
7	Nil	Nil	Nil	Medium	Windows 98	MSIE
8	3 y	7 y	14 y	Competent	Windows 95	Netscape
9	Some	Competent	Experienced	Competent	Windows 95	MSIE
10	Substantial	Substantial	13 y	High	MacOS	Netscape

The range of experience was considerable with particular strength in teaching and some limitations in experience of software design. The levels of self-reported computing skill were varied and provided a suitably representative group. Both target operating systems were represented and both Windows browsers were represented. Although, in view of the heuristic method being used, more experience in software design might have been desirable for the beta evaluation, the group had sufficient breadth to provide useful responses across all areas of the evaluation.

Early feedback from the evaluators revealed that their experiences with the IMM-PBL CD-ROM varied substantially. Some reported no difficulty in accessing the materials while others, despite following the instructions provided for installation and use, apparently experienced problems with the operation of their browser and associated components. It was at this stage that the problems with the materials in Internet Explorer for Windows, as described in Chapter 3, were first reported.

Results are reported separately for the three sets of heuristics. In each case the responses on the rating scales are presented in a table followed by a summary of the main points raised by the evaluators in their comments about each heuristic. In each table the distribution of ratings is provided along with the median rating. Where an evaluator did not rate on a scale the response is included in the 'Nil' column. Table 5.24 summarises the responses to the rating scales for the interface design heuristics.

Table 5.24: Ratings on interface design heuristics

	Heuristic	**1**	**2**	**3**	**4**	**5**	**N/A**	**Nil**	**Median**
1	Ensures visibility of system status		1		3	6			5.0
2	Maximises match between the system and the real world				2	8			5.0
3	Maximises user control and freedom			3	4	2		1	4.0
4	Maximises consistency and matches standards					8		2	5.0
5	Prevents errors				5	2		3	4.0
6	Supports recognition rather than recall				4	5		1	5.0
7	Supports flexibility and efficiency of use		2		2	3	2	1	4.0
8	Uses aesthetic and minimalist design				1	8		1	5.0
9	Helps users recognise, diagnose and recover from errors			1		2	4	3	5.0
10	Provides help and documentation			1	1	5	1	2	5.0

Overall the response to the interface design was very positive with no items recording a median rating less than 4.0. Caution is required in interpreting the ratings for items on which 30% or more of the respondents did not provide a rating or used N/A (items 5, 7, 9 and 10). Of the remaining six items, five recorded median ratings of 5.0, indicating that, in the opinion of the respondents, the user interface had few serious problems in respect of the heuristics that were applied.

Most of the comments related to navigational issues, especially working out what to do next and reviewing content which had been accessed previously. Subsequent discussions with some of the evaluators revealed that they had failed to access one or both of the help system and the folders, which may have solved those respective problems. Those who had accessed the help facility offered suggestions about how the inclusion of more specific help might assist.

Some users reported errors when attempting to access help or other parts of the materials. On further investigation these problems were found to be related to the issues with the use of JavaScript in the Windows version of Internet Explorer as described in Chapter 3.

Table 5.25 summarises the responses to the rating scales for the educational design heuristics.

Table 5.25: Ratings on educational design heuristics

	Heuristic	1	2	3	4	5	N/A	Nil	Median
11	Clear goals and objectives		1	2	3	3		1	4.0
12	Context meaningful to domain and learner			1	3	6			5.0
13	Content clearly and multiply represented and multiply navigable				5	3		2	4.0
14	Activities scaffolded			1	4	5			4.5
15	Elicit learner understandings				3	4	1	2	5.0
16	Formative evaluation	1		2	2	3	1	1	4.0
17	Performance should be 'criteria-referenced'			2	2	3	2	1	4.0
18	Support for transference and acquiring 'self-learning' skills				4	5		1	5.0
19	Support for collaborative learning				2	6	1	1	5.0

The overall response to the educational design was also quite positive with all nine of the items recording median ratings of 4.0 or greater and four of them with medians of 5.0. As noted above, caution should be applied to the interpretation of ratings for items (15 and 17) where 30% of the respondents did not apply a rating.

Key issues raised in the comments for item 11 related to making the objectives more explicit, providing an overview of the materials and facilitating access to the objectives and information about the package from any point within it. In relation to item 16, some users commented about the comparative nature of the feedback and thought that it might be advantageous to provide clearer guidance as to what was exemplary in the sample responses. Some reviewers noted that although there was opportunity for virtual interaction with the consultants there was no explicit encouragement to work collaboratively with other users although that might be part of the context in which the materials were used.

Table 5.26 summarises the responses to the rating scales for the content design heuristics.

Table 5.26: Ratings on content design heuristics

	Heuristic	1	2	3	4	5	N/A	Nil	Median
20	Establishment of context				3	6		1	5.0
21	Relevance to professional practice			1	3	5		1	5.0
22	Representation of professional responses to issues			1	1	5	1	2	5.0
23	Relevance of reference materials				3	4	1	2	5.0
24	Presentation of video resources	1			1	5	1	2	5.0
25	Assistance is supportive rather than prescriptive			1	3	3	1	2	4.0
26	Materials are engaging				3	5		2	5.0
27	Presentation of resources				1	6	1	2	5.0
28	Overall effectiveness of materials			1	4	4		1	4.0

Overall the ratings on the content design heuristics were extremely positive. All but two items (25 and 28) recorded median ratings of 5.0. As noted above, caution should be applied to the interpretation of ratings for items (22, 23, 24, 25 and 27) where 30% of the respondents did not apply a rating. However, on most items, the high level of agreement among the remaining respondents lends confidence to the results.

There were numerous positive comments about the quality and relevance of the materials, especially the use of authentic material from teachers. One reviewer expressed concern about embedding the tasks in a job-application context. Another noted that there would be a need to update references to specific examples of computer hardware and software as technology continued to advance.

As with the user evaluations of the prototype, the beta evaluation confirmed the value of the overall design and content of the IMM-PBL materials. It also assisted in identifying problems that required resolution before a final version could be completed.

The most serious problem identified in the materials was the failure of the JavaScript code in the Windows version of Internet Explorer. As described in Chapter 4, further investigation revealed that the problem was related to the security model in that browser environment. The problem was resolved by changing the mechanism used to retain data within the materials.

Failure by some users to access the help system or the folders suggested that those features might not be sufficiently accessible or visible to the user. A new button giving access to the folders was introduced in the help area at the bottom left of the screen. In order to draw attention to the availability of the help system, new code was added so that when a new user first logged in, the help window would open and display a message advising the user about the use of the help system.

5.5 Evaluation trial

The analysis of data collected in association with the evaluation trial of the IMM-PBL materials will be considered in three categories. The first set of analyses is of data collected by administration of the Likert scale items in a mass lecture prior to the software trials. The second set of analyses will compare the pretest and posttest data obtained for the participants in the evaluation with those for a control group selected from students enrolled in the same courses but not studying the subject in which the software trial was located. Finally, additional evaluative data collected from the participants in the trial will be considered.

5.5.1 Data from the large group

The multi-instrument questionnaire was administered during a mass lecture in the first week of semester to students enrolled in a final year subject required for all students in the Bachelor of Education programs. A total of 178 responses was collected.

5.5.1.1 The respondents

Most (62%) of the respondents were pre-service Primary teachers enrolled in the four year undergraduate (55%) or two year graduate entry (7%) degrees. A further 26% were enrolled in Early Childhood undergraduate (25%) or graduate entry (1%) degrees and the remainder (12%) were pre-service Secondary teachers.

The fourth year undergraduate Primary (N = 98) and Early Childhood (N = 45) students in this group belonged to the same cohort of students who had participated in an earlier study (Albion, in press) during their first year in the program. No attempt has been made to isolate the data for students who may have participated in both studies for purposes of comparison in this study.

The majority of the respondents were female (82%). Most (75%) reported their age as less than 25 years, with 35% aged less than 21 years and 40% between 21 and 25 years. A further 10% were aged from 26 to 30 years with the remainder (15%) aged more than 30 years. The high proportion aged less than 25 years suggests that most were traditional students who had entered their university course directly from secondary school.

For most of the respondents (74%), the only computer-related subject studied at university was the compulsory core unit usually taken in first year, although some (14%) reported that they had studied five or more computer related subjects. Almost all respondents (92%) reported having access to a computer at their residence during semester; 72% reported Windows and 20% Macintosh systems. In the previous study at USQ (Albion, in press), analysis of posttest data (N = 110) found that 78% had access to a computer at their residence during semester; 54% Windows and 16% Macintosh. That study reported that there had been an increase in access (from 58% to 78%) over the first year of university study. Data from the current study suggest that access has continued to increase during subsequent years of study.

Computer use in a typical week was reported as: less than one hour (12%), 1 to 5 hours (46%), 6 to 10 hours (26%) and more than 10 hours (16%). The comparable values from the previous study (Albion, in press) were: less than one hour (21%), 1 to 5 hours (43%), 6 to 10 hours (22%) and more than 10 hours (14%). That study reported a significant increase in hours of computer use during the first semester of study and that increased level appears to have remained stable over three years.

5.5.1.2 Scale reliabilities and results

Table 5.27 lists the Cronbach's alpha reliability coefficients, means and standard deviations calculated for the Likert scale data obtained from the administration of the multi-instrument questionnaire to the entire class. Because, for this administration as described in Chapter 3, the scales for all instruments were reduced to four-point Likert scales, the maximum value on each scale was 4.

Table 5.27: Alpha reliability, mean and SD for large group (N = 178)

Instrument	Sub-scale	Reliability (alpha)	Mean	SD
MUTEBI	Outcome expectancy (OE)	.74	2.66	.40
	Self-efficacy (SE)	.88	3.00	.45
ACT	Comfort/Anxiety	.89	2.98	.65
	Usefulness	.76	3.36	.42
SCT	E-mail	.98	3.31	.83
	Internet	.94	3.02	.88
	Word processing	.94	3.67	.49
	Operating system	.91	3.26	.72
	Spreadsheet	.96	3.22	.85
	Database	.98	2.98	.94
	CD-ROM	.96	2.65	.93
	SCT composite	.98	3.20	.63
PCI		.66	2.09	.37
Teacher Efficacy	External	.74	2.21	.37
	Internal	.75	2.87	.32
Innovativeness		.85	3.11	.43

The reliability estimates are generally similar to those reported for the administration of the same instruments in association with the prototype trial. However, there are noticeable differences in some values. Reliabilities for the word processing and operating system scales are somewhat higher (.94 and .91) than obtained in the prototype trials (.83 and .84). The reliability of the Innovativeness scale (.85) is also higher for this administration than was found previously (.71) but the reliabilities for the Teacher Efficacy scales (.74 and .75) are slightly lower than in the prototype trial (.81 and .82). All scales, including those modified to use a four point scale, appear to be reliable.

The means recorded on the various scales were compared to those reported for the administration of the same instruments at the time of the 1997 prototype trial. For the MUTEBI, PCI, Teacher Efficacy and Innovativeness scales, the results obtained on the previous administration were transformed to equivalent values on a four point scale prior to comparison. Table 5.28 shows the means and standard deviations recorded for administration of the scales during the prototype trial (1997) and the evaluation trial (2000).

Table 5.28: Comparison of 1997 and 2000 scores for the multi-instrument questionnaire

		1997 group (N = 31)		2000 group (N = 178)				
Instrument	**Sub-scale**	**Mean**	**SD**	**Mean**	**SD**	**t**	**df**	**p**
MUTEBI	Outcome expectancy	2.96	.42	2.66	.40	-3.83	207	.000
	Self-efficacy	2.68	.43	3.00	.45	3.68	207	.000
ACT	Comfort/Anxiety	2.79	.54	2.98	.65	1.54	207	.126
	Usefulness	3.42	.30	3.36	.42	-.76	207	.447
SCT	E-mail	2.31	1.12	3.31	.83	5.85	207	.000
	Internet	2.29	1.02	3.02	.88	4.16	207	.000
	Word processing	3.64	.45	3.67	.49	.32	207	.751
	Operating system	3.08	.67	3.26	.72	1.30	207	.196
	Spreadsheet	3.09	.71	3.22	.85	.80	207	.423
	Database	2.96	.79	2.98	.94	.11	207	.911
	CD-ROM	2.62	.80	2.65	.93	.17	207	.866
	SCT composite	2.90	.61	3.20	.63	2.46	207	.015
PCI		2.11	.32	2.09	.37	-.28	207	.777
Teacher Efficacy	External	2.03	.39	2.21	.37	2.48	207	.014
	Internal	3.02	.35	2.87	.32	-2.38	207	.018
Innovativeness		3.01	.32	3.11	.43	1.24	207	.218

The 2000 respondents reported significantly higher self-efficacy for computer use as measured by the SCT composite scale. This difference results from very significant increases in self-efficacy for use of e-mail and Internet, which were the only sub-scales of the SCT to show significant differences. Students completing their degree in 2000 have had more exposure to the Internet than had students who completed in 1997, both through use of the Internet in their courses and as a consequence of increasing public awareness of and access to the Internet during the period from 1997 to 2000.

There are smaller, but statistically significant, differences in the results for both factors of the Teacher Efficacy scale. These differences suggest that, compared to the 1997 group, the second group of students may be slightly less confident of their capacity for personal influence in teaching and slightly more inclined to believe in the influence of factors beyond the direct control of the teacher. There are statistically significant differences between the two groups for both sub-scales of the MUTEBI. Belief in the capacity of teachers to influence pupils' ability to use the computer as measured by the MUTEBI OE scale is significantly less for the 2000 group. At the same time they are significantly more confident than the 1997 group of their own ability to use the computer effectively for teaching, as measured by the MUTEBI SE.

Neither the differences on the Teacher Efficacy scale nor those on the MUTEBI measures have any obvious explanation. The structure of the degree program has been stable over the intervening years, although there have been some changes in teaching staff and consequent minor adjustments to the presentation of program elements. Further studies might reveal whether the differences indicate a trend or are simply a fluctuation associated with the particular cohort of students.

The descriptions applied to the respondents in the prototype trial are also true of this group. They are generally comfortable with computers and the use of common applications and believe in the value of computers for teaching. Compared to the other group, they are more confident of their ability to teach with computers but there is scope for further increase.

5.5.1.3 Relationships among the variables

As noted previously, the study sought to investigate the effects of IMM-PBL on self-efficacy for teaching with computers as measured by the SE scale of the MUTEBI. Thus it was important to determine which of the other variables might be related to SE. Pearson product moment correlation coefficients were computed for pairs of measures. The results are shown in Table 5.29.

Table 5.29: Correlation coefficients for pairs of scales (N = 178)

	Comfort	Usef.	SCT	PCI	OE	SE	Ext.	Int.
Usefulness	.50***							
SCT	.70***	.46***						
PCI	-.15*	-.35***	-.07					
OE	.12	-.02	.18*	.21**				
SE	.64***	.60***	.56***	-.23**	.14			
External	-.07	-.33***	-.03	.39***	.09	-.39***		
Internal	.13	.09	.22**	.00	.43***	.26**	-.13	
Innovativeness	.22**	.37***	.20**	-.38***	.07	.45***	-.52***	.16*

* p < .05 ** p < .01 *** p < .001 (2-tailed)

It is evident from Table 5.29 that there are several significant correlations. For the purposes of this study, which is concerned with the possible effects of IMM-PBL on self-efficacy for teaching with computers, the correlations involving the MUTEBI sub-scales, especially SE, are of primary interest.

Compared to the pattern of correlations found in the data collected in association with the prototype trial, there are several notable differences. Previously OE was significantly correlated with both sub-scales of the ACT but those correlations are not significant in these data. Instead, OE is significantly correlated with PCI and the internal factor of Teacher Efficacy. Respondents with a preference for more custodial approaches to classroom management and a stronger belief in the personal capacity of teachers to influence outcomes appear to be more confident of the capacity of teachers to influence pupils' ability to use computers effectively. The correlation of OE with PCI is consistent with expectations based on previous research (Enochs et al., 1995).

SE was significantly correlated with each of the other variables except OE. Moreover, many of those variables were significantly correlated with each other. The potential influences of other variables on SE were important in this study since, if SE were to be strongly influenced by relatively stable factors, there might be less potential for IMM-PBL to effect changes in SE.

In order to clarify the relative predictive influence of other variables on SE, backward multiple regression was applied. SE was entered as the dependent variable. SCT, both sub-scales of the ACT, PCI, Innovativeness, the two sub-scales of teacher efficacy, age, gender, number of university computer subjects studied and weekly hours of computer use were entered as independent variables and backward regression analysis was applied. Six variables were retained by the analysis in a model which accounted for 61% of the variance ($R^2 = .61$, $F [6, 161] = 42.24$, $p < .00005$).

Table 5.30 shows the results for the final regression model. Of the six variables remaining in the model, scores on the ACT and SCT sub-scales have been previously found to be positively associated with computer use (Albion, in press). Any gains in those scores as a result of working with the IMM-PBL materials might be expected to contribute to an increase in SE. Although there is no evidence that Teacher Efficacy or Innovativeness would be affected by working with the IMM-PBL materials, it is conceivable that exposure to successful exemplars of innovative teaching practice might impact positively on users' attitudes. Thus, there is no reason to consider that any of these predictors of SE should impact negatively on the effects of the IMM-PBL intervention. A more complete discussion of the implications of these relationships is provided in Chapter 6.

Table 5.30: Final regression model for SE sub-scale of MUTEBI

		B	SE B	Beta	T	Sig T
ACT	Comfort	.239	.051	.341	4.72	.0000
	Usefulness	.238	.069	.219	3.45	.0007
SCT		.112	.051	.156	2.19	.0303
Teacher efficacy	External	-.265	.074	-.211	-3.60	.0004
	Internal	.152	.071	.108	2.13	.0347
Innovativeness		.148	.062	.142	2.39	.0178
(Constant)		.810	.395		2.05	.0420

5.5.2 Pretest-posttest comparison

As discussed in Chapter 3, to minimise the work required of respondents, the posttest administration of the questionnaire did not include the instruments for which changes as a result of working with the IMM-PBL materials were not anticipated. Thus the PCI, Teacher Efficacy and Innovativeness scales were omitted from the posttest version of the questionnaire.

Forty-five students were enrolled in the subject within which the software trial was located. All had completed the pretest questionnaire. These comprised the experimental group. Fifty students, who were enrolled in the same programs as the experimental group but were not enrolled in the subject including the software trial, were randomly selected from among the remaining students who had completed the pretest questionnaire. These comprised the control group. Posttest questionnaires were distributed as described in Chapter 3.

Forty-nine completed questionnaires were returned; 22 from the experimental group and 27 from the control group. These represent response rates of 49% and 54% respectively. Although the response rates were low, comparisons of the demographic data for the respondents, as described below, confirmed that the two groups were reasonably equivalent and representative of the population from which they were drawn.

Using the identifying data on the forms, the returns were matched with the data from the earlier administration to create a single data set comprising the pretest and posttest data for the 49 respondents to the posttest.

Data from the pretest were compared for the experimental and control group respondents to verify that they were reasonably equivalent. Chi-square procedures were used for categorical data such as gender, age and weekly hours of computer use. Numeric data were compared using t-test procedures.

The only significant difference found between the two groups of respondents was the gender composition ($\chi^2 = 5.499$, df = 1, p = .019). The respondents from the experimental group included 6 males (27%), compared to just one male (4%) among the respondents from the control group.

Data for the experimental group pretest were also compared with data for the entire group which responded to the pretest (N = 178). There were no significant differences found. These analyses support the conclusion that the experimental and control group respondents were equivalent on the measures under investigation, differing only in their enrolment in the subject using the IMM-PBL materials, and that the respondents from the experimental group were representative of the population of final year pre-service teachers at USQ.

5.5.2.1 Likert scale instruments

Mean scores obtained by the experimental and control groups on the pretest and posttest were compared using paired samples t-tests. The results are shown in Table 5.31.

Table 5.31: Mean scores on pretest and posttest

Control group		**Pretest**		**Posttest**				
(N = 27)		**Mean**	**SD**	**Mean**	**SD**	**t**	**df**	**p**
MUTEBI	OE	2.48	.41	2.75	.55	2.59	26	.015
	SE	2.93	.47	2.88	.58	.72	26	.475
ACT	Comfort	2.93	.72	2.85	.67	.97	26	.339
	Usefulness	3.38	.43	3.42	.40	.46	26	.649
SCT	SCT	3.10	.66	3.08	.52	.22	26	.824
Experimental group		**Pretest**		**Posttest**				
(N = 22)		**Mean**	**SD**	**Mean**	**SD**	**t**	**df**	**p**
MUTEBI	OE	2.61	.44	2.83	.39	4.39	20	.000
	SE	3.06	.41	3.08	.47	.22	21	.830
ACT	Comfort	2.97	.75	3.13	.62	1.73	21	.097
	Usefulness	3.49	.36	3.51	.38	.29	21	.778
SCT	SCT	3.20	.67	3.36	.64	2.08	21	.050

Both the control group ($t = 2.59$, $df = 26$, $p = .015$) and the experimental group ($t = 4.39$, $df = 20$, $p < .001$) had significant increases for the outcome expectancy sub-scale of the MUTEBI. However, independent samples t-tests found no significant difference between the control group and the experimental group on either the pretest or the posttest. Since the increase in OE occurred for both the control and experimental groups it must be caused by one or more factors other than the IMM-PBL intervention. It is possible that either awareness of the IMM-PBL trial or activities in other subjects have raised students' awareness of the importance of computers in teaching and that this is reflected in the increased values for OE.

The experimental group recorded a significant increase in SCT ($t = 2.08$, $df = 21$, $p = .050$) whereas the control group recorded an insignificant decrease. Further investigation of the SCT scores revealed that the experimental group had registered increases on each of the seven sub-scales, although only the increases for CD-ROMs ($t = 2.79$, $df = 21$, $p = .011$) and Internet ($t = 3.02$, $df = 21$, $p = .007$) were statistically significant. The control group had registered increases on the Internet and OS sub-scales and decreases on the remaining sub-scales, although none of the changes were statistically significant.

The failure of the criterion variable (SE) to register any apparent change as a result of the IMM-PBL intervention prompted closer examination of the results. A scan of the data confirmed that, although the pretest means of SE for both the experimental and control groups were close to 3.0, both groups included values above 3.5. It was possible that the limited range available for increase in the value of SE for these participants may have restricted any increase in the mean as a result of the IMM-PBL intervention.

Self-efficacy theory (Bandura, 1986) predicts that self-efficacy beliefs may be influenced by either successful or unsuccessful performance. Persons with initially low self-efficacy may have their self-efficacy increased following successful experience. Those with initially high self-efficacy may decrease their estimates if an activity proves more difficult than they had assumed. In this instance it was possible that some students may have reported high SE scores based on limited knowledge and experience and that exposure to the IMM-PBL may have caused them to revise their estimates downwards. On the other hand, students who commenced with low SE may have increased their SE on the basis of success with the materials. Hence it was decided to investigate whether there was any differential effect for students who had initially high or low SE scores.

The experimental and control groups were each divided into two groups with high and low values of initial SE. The median SE score (SE_{median} = 2.929) for the combined groups was used as the criterion. Figure 5.1 illustrates the pretest and posttest values of SE recorded for each of the four groups formed by the median split.

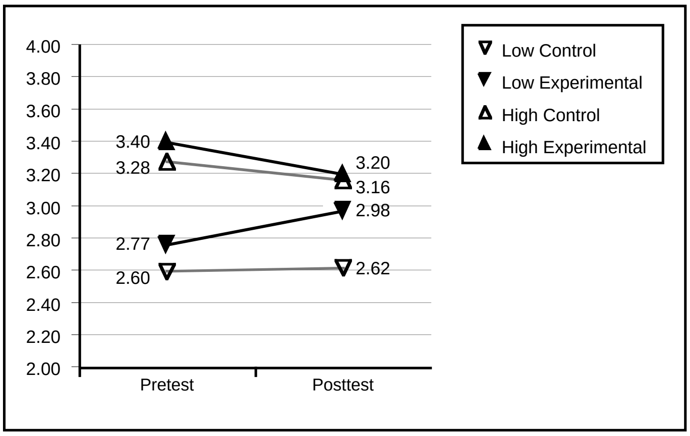

Figure 5.1: Pretest and posttest mean SE scores by initial SE group

Both high SE groups (experimental and control) recorded similar decreases in SE on the posttest measure. Both low SE groups recorded increases, although the increase for the experimental group was markedly more than for the control group. Statistical regression towards the mean is a common threat to internal validity (Vockell & Asher, 1995, p. 228) and is a possible explanation for the changes observed in Figure 5.1.

In order to test for significant difference between the observed increases for the low initial SE group under the experimental and control conditions, difference scores were calculated for SE. Data screening using the SPSS Box Plots procedure identified an outlier in the experimental group. That case was removed before a t-test for independent samples was applied to test for differences between the experimental and control groups in the amount of increase in SE. A statistically significant difference ($t = 2.71$, $df = 23$, $p = .013$) was found for the difference in the changes in SE for the low initial SE condition in the experimental and control groups.

5.5.2.2 Open-ended questions

As described in Chapter 3, the multi-instrument questionnaire included six open-ended questions framed around the categories identified in the analysis of the consultant interviews. For both pretest and posttest the responses to each question were read and coded for the corresponding sub-categories from the analysis of interviews. The coding process recorded only whether the responses contained statements that related to each sub-category. Hence for each respondent, each sub-category was coded as 0 for absent or 1 for present.

Separate chi-square analyses were performed on the data from the pretest and posttest to determine if significant differences existed between the control and experimental groups. Table 5.32 records the frequency counts obtained for each sub-category on the pretest and posttest together with chi-squared and significance values for differences between control and experimental groups.

Table 5.32: Frequencies of response categories for open-ended questions

	Pretest				Posttest			
N =	Con. 27	Exp. 22	χ^2	p	Con. 27	Exp. 22	χ^2	p
Purpose								
Vocational	4	3	.014	.907	2	1	.173	.678
Future society	8	9	.681	.409	13	11	.017	.897
Potential	13	11	.017	.897	16	15	.415	.519
Development								
Pre-service	1	2	.612	.434	0	0	–	–
Inservice	17	9	2.367	.124	22	9	8.586	.003
Reading	0	5	6.834	.009	2	7	4.82	.028
Experience	7	10	2.040	.153	12	16	3.960	.047
Networking	2	5	2.324	.127	3	10	7.335	.007
Confidence	0	0	–	–	0	0	–	–
Teacher first	1	0	.832	.362	0	0	–	–
Learning from children	0	2	2.559	.110	1	0	.832	.362
Method								
Integration	0	3	3.922	.048	2	4	1.310	.252
Multiple activities	0	2	2.559	.110	2	3	.513	.474
Independent learning	0	0	–	–	0	1	1.253	.263
Matching	10	13	2.367	.124	13	15	1.987	.159
Incremental	0	0	–	–	0	0	–	–
Structure	2	0	1.699	.192	4	5	.506	.477
Impact								
Motivation	2	6	3.810	.051	3	6	2.112	.146
Efficiency	8	6	.033	.856	11	6	.970	.325
Work quality	1	2	.612	.434	3	2	.064	.816
Growth - teacher	0	2	2.559	.110	3	2	.054	.816
Growth - children	6	6	.167	.683	16	10	.928	.336
Issues								
Resources	5	6	.534	.465	11	6	.970	.325
Time	3	4	.495	.482	1	3	1.595	.207
Technical	3	2	.054	.816	6	4	.122	.727
Behaviour	0	0	–	–	2	3	.513	.474
Internet								
Communication	3	1	.697	.404	2	0	1.699	.192
Information	13	13	.583	.445	23	18	.101	.751

There are few significant differences evident in Table 5.32. Other than more frequent reference to *integration* by the experimental group (p = .048) on the pretest, the significant results are all within the *development* category. The experimental group made significantly more references to *reading* as a form of development on the pretest (p = .009) and that difference was present, though less significant, in the posttest (p = .028). The control group made more frequent reference to *inservice* on the posttest (p = .003). The experimental group referred more frequently to *networking* with colleagues (p = .007) and to practical *experience* with computers (p = .047) as methods of professional development.

5.5.3 Additional evaluative data

Three additional forms of data were sought from students in the group who worked with the IMM-PBL materials. An evaluation questionnaire was presented to each of the participants at the conclusion of the trial. Participants were also asked to maintain journals during their use of the materials and were invited to participate in brief interviews during the final trial sessions. Data obtained from these sources are described in this section.

5.5.3.1 User evaluation questionnaire

As described in Chapter 3, the user evaluation questionnaire employed in the evaluation trials was a slightly modified version of the instrument used in the prototype trial. It was distributed to the experimental group with the multi-instrument questionnaire. Twenty-four responses (53% response rate) were received.

The slight difference from the number of responses for the multi-instrument questionnaire resulted from two respondents completing the evaluation but not the other questionnaire. As for the multi-instrument questionnaire, in general terms the respondents were representative of the population from which they were drawn. However, it is possible that they had chosen to respond because they held strong opinions, one way or the other, about the experience of working with the IMM-PBL materials. Hence, they may not be entirely representative of the typical user response to the materials.

Table 5.33 summarises the results obtained for the twenty Likert scale items on the questionnaire. Items for which the numbers are underlined were reverse scored. The table shows the number of responses recorded for each point on the scale together with median ratings.

Table 5.33: User evaluation data for the completed IMM-PBL (N= 24)

No.	Item	SD 1	D 2	N 3	A 4	SA 5	Nil	Median
1	I was enthusiastic about using the multimedia package as a part of my study			7	11	6		4.0
*2	The problems presented in this multimedia package were NOT closely related to the everyday experience of teaching	4	11	5	3		1	4.0

No.	Item	SD 1	D 2	N 3	A 4	SA 5	Nil	Median
*3	The problems presented in this multimedia package were relevant to my future work as a teacher		1	2	15	5	1	4.0
*4	Using this multimedia package helped to increase my confidence for making professional decisions	1	2	4	15	2		4.0
5	Using this multimedia package helped to improve my knowledge of classroom management	1	5	3	13	2		4.0
<u>6</u>	Working with this multimedia package did <u>NOT</u> help me to prepare better for using technology in my classroom	2	16	4	1	1		4.0
7	Using this multimedia package helped to improve my understanding of integrating technology into teaching	1	1	3	18	1		4.0
8	Using this multimedia package increased my confidence for dealing with related issues in my own classroom	1	1	6	13	3		4.0
9	In my opinion this type of multimedia package is a very effective learning tool	1		4	14	4	1	4.0
10	The quality of the sound on this multimedia package is very good		2	3	14	5		4.0
11	The visual quality of the video presented on this multimedia package is very good		1	1	15	7		4.0
*12	The operating instructions included with the multimedia package were sufficient to allow me to use it effectively		2	2	17	3		4.0
13	The textual materials on the multimedia package were of high quality			3	18	3		4.0
<u>*14</u>	The multimedia package did <u>NOT</u> provide adequate feedback for the included tasks	4	8	7	5			3.5
*15	The problems on the multimedia package progressed in a logical fashion		1		21	2		4.0
16	Navigation through the multimedia package was <u>NOT</u> difficult	1	1		17	5		4.0
*17	I was easily able to find sufficient time to work through the tasks	1	14	5	4			2.0
*18	The resources on the multimedia package were easy to access	1	3	1	14	5		4.0
*19	The visual design of the multimedia package was attractive and functional	1			16	7		4.0
*20	The multimedia package was easy to use	1	1	4	14	4		4.0

* Marked items have been varied from those used in the prototype trial.

User response to the materials was generally positive. Respondents reacted very favourably to the presentation of the materials (items 10, 11, 13 and 19) and perceived them as highly relevant to their professional preparation (items 2, 3, 4, 5, 6, 7 and 8). Only two of the items recorded median ratings less than 4.0.

Item 14 (median = 3.5) referred to the adequacy of feedback for the tasks in the materials. The median score for the equivalent item in the prototype trial was 3.0 and was explained in terms of some sample responses being missing from the prototype. Inclusion of the remaining sample responses may explain the improvement in the rating for the final version but a substantial number of users still perceived the feedback as inadequate. The open-ended nature of the tasks included in the IMM-PBL materials does not lend itself to any simple solution for providing more specific feedback on users' responses to tasks. A future revision of the materials might do well to include at least some tasks for which more specific feedback would be possible or make more explicit provision for users to receive feedback from a tutor or other users.

Item 17 (median = 2.0) referred to the relative ease with which participants in the trial were able to find time to work through the materials. The total of 8 to 10 hours available for students to work with the materials during the laboratory sessions was anticipated to be sufficient for students to work through some, but not all, of the scenarios depending upon the degree to which they explored the available resources in the package. Technical problems in the first two weeks of laboratory sessions increased the pressure on available time to the point where most students felt they had insufficient time to work through the materials. Given the generally positive response to the materials, it is possible to interpret the rating on this item as positive in the sense that participants did not feel they had exhausted the potential of the materials in their relatively brief interaction.

Table 5.34 summarises the responses to items 21 to 27, which asked users to indicate how they thought a change in the amount of various elements might improve the overall package.

Table 5.34: Desirability of content elements in the completed IMM-PBL (N = 24)

No.	Resource type	Much less			Much more		Nil	Median
		1	2	3	4	5		
21	Text resources	1	2	15	6			3.0
22	Audio (without video)	2	3	11	7	1		3.0
23	Video		1	9	10	4		4.0
24	Photographs	1	3	9	10	1		3.0
25	Drawings	1		8	12	3		4.0
26	Theoretical background	1	1	12	9	1		3.0
27	Sample solutions		1	5	11	7		4.0

The median values of the responses suggest that respondents saw elements such as text, audio, photographs and theoretical background as being present to an acceptable degree with limited scope for an increase in quantity to improve the overall package. When the pattern of responses for items with median scores of 4.0 is considered, the implied ranking of elements is similar to that obtained for the prototype, with sample solutions, drawings and video being favoured for expansion.

The strongest response in favour of additional inclusions was for sample solutions. This is consistent with the response to item 14, which indicated that users saw a need for more feedback. It appears that additional feedback of the existing type, sample solutions, might be welcomed by users but it is not possible to say whether a simple increase in the quantity of feedback, rather than a change in its nature, would be sufficient to address the issues raised by item 14.

Item 37 in this questionnaire asked users to mark those aspects of teaching and planning for teaching for which working with the IMM-PBL materials had enabled them to gain some insight. Table 5.35 summarises the responses for this item as raw frequencies and as the percentage of respondents who selected each aspect. Four respondents did not mark any of the aspects of teaching in the list.

Table 5.35: Nomination of aspects of teaching in the completed IMM-PBL (N = 24)

Aspect of teaching	f	%	Aspect of teaching	f	%
teachers' self organisation	15	63	physical layout of a classroom	18	75
classroom management	17	71	room arrangements	15	63
travel patterns	5	21	arrangements of desks	15	63
use of other personnel	16	67	teaching strategies	15	63
teachers' knowledge of technology	18	75	selection of appropriate strategies	12	50
sequencing of activities	9	38	teaching skills	11	46
integrating content	16	67	managing small groups	7	29
dealing with diverse groups of children	9	38	checking for understanding	9	38
assessing student work	7	29			

Comparison with the results obtained for the prototype trial revealed that the eight most frequently selected aspects were consistent across the two sets of data, although there were some changes in ranking. The emphasis in the prototype responses on aspects associated with the arrangement of equipment in classrooms was probably related to the impact upon users of the task requiring them to manipulate equipment in a classroom plan. Responses for the final version were less focused on those aspects, presumably as a result of a broader range of tasks being included in the final version. Compared to the prototype trial, there were increased frequencies of selection for the items related to teaching strategies and skills. Participants in both trials appeared to consider that they had gained some insights relevant to teaching from the materials.

The remaining items on the questionnaire were open-ended. These responses were collated and examined for trends and noteworthy comments.

Item 28 asked about users' **first impressions of the materials**. Almost all users reported their initial impressions as being positive, using phrases such as "well presented", "easy to use" and "very interesting". Four of the responses reported a negative first impression based on the technical problems being experienced in the laboratory when they first used the CD-

ROM. One commented that "once I got into it I found it really enjoyable and informative" and listed several specific sections that had particular appeal.

Answers to item 29, which asked how they would **describe the materials to a colleague**, mostly included references to the video content, the job applications, integration of computers in teaching and the large quantity of information. Particular comments referred to "role playing", "real life video responses" to questions and to how the materials "put you into thinking mode as a teacher".

Of 21 responses to item 30, which was about users' **favourite part of the materials**, 15 referred to the video interviews. The next strongest impression was made by the job applications, which attracted 4 responses. Comments noted how the "videos made it feel real" and that the "voices and videos made it credible and enjoyable". Some students commented specifically that the videos were better than reading and that they would be less inclined to work with text materials.

For item 31, the majority of **identified weak points** related to the technical issues experienced in the laboratory used for the trials. Problems with sound and video and especially with the lack of persistence of the cookies accounted for almost all of the weaknesses mentioned. The only true design, as opposed to access environment, issues raised were three mentions of inability to easily move from one location to another location in the materials other than by a specified path. **Suggestions for improvement**, made in response to item 32, generally mirrored the comments about observed weaknesses, although one student suggested having access to sample responses before being required to attempt a task.

Thirteen of 21 responses to item 33 identified some aspect associated with applications for employment or selection criteria as the **greatest benefit from the package**. Six responses referred to preparation for working as a teacher, especially in relation to ways of using IT and thinking like a teacher. One user observed that the materials provided "experience in activities you don't usually get on prac" and another noted that "it made me think about computers in classrooms as a reality, now today, not just one day a week if lucky". The latter comment appeared to be related to the practice in some schools of placing computers in laboratories and scheduling classes on a weekly basis. This participant seems to be expressing a preference for a more integrated approach on the basis of alternative practices presented in the IMM-PBL materials.

In response to item 34, which was about **benefits for professional development**, there were mentions of preparation for future work, applications for employment and "exposure to experienced teachers in the package". Students offered comments such as "it provides hands on experience using real life scenarios, enables me to learn from professionals already in the field", "lets me see how other teachers operate, solve problems and integrate computer technology". One user commented on the benefit of "directly seeing the effect of learning through interactive material, an exciting way to learn" and another noted the inclusion of "alternate responses to the same questions - different doesn't mean wrong."

In responding to item 35, users were able to identify **specific aspects of teaching with IT learned through working with the materials**. Common ideas related to curriculum integration and classroom layouts to accommodate computers. One response referred to learning about "scheduling students on the computer all the time" in contrast to a prior concept of using the computer only in "spare time". Another mentioned new awareness of the possibility of uses of computers apart from Mathematics, for example in language or history classes. A user who had previously "thought only about student use, not teacher use" became aware of the possibilities the computer offered for planning. Item 36, which asked about the **insights possible for other teachers**, attracted a similar range of responses to item 35.

In a final comment one student remarked that "personally I come from a totally illiterate computing background but am encouraged and excited about the ways that I could use multimedia technology in enhancing students' learning experiences".

5.5.3.2 Participant journals

Fifteen of the students who responded to the questionnaires also submitted the journals they had maintained during their use of the IMM-PBL materials. As supplied to the students, the journal format provided for a separate page to be recorded each time that the student worked with the materials. Most of the students submitted four pages corresponding to four class sessions in which they had used the materials. A few had missed a session and submitted three pages and, in one case, just two pages.

Each journal page had space to record the amount of time spent with the materials in the session reported on that page. Total times reported by each student ranged from 2.5 hours to 10 hours with a mean of 6.2 hours and standard deviation of 1.9 hours. Thus the mean time for which students interacted with the materials was slightly less than the 8 hours available during the four laboratory sessions in which the IMM-PBL materials were the assigned activity.

Although the journals included occasional mention of the technical difficulties experienced in the laboratory, few of the students dwelt on those issues. The descriptions, especially of the first session, suggest that, for some students, there was a good deal of exploratory activity before they began in earnest on the problems. Comments typical of this group included:

> I have just moved around flicking on the different areas to see what is there.
>
> … it was basically click and see what happened next!
>
> In this session I had a general overall look at the different parts of the CD, looked at video clips, help section and tasks.

Extracts from the journals of four participants are presented below. The selection was made on the basis of the amount of description included in the journals and their capacity to illustrate contrasting approaches taken by different participants to working with the IMM-PBL materials. The participants are identified below as A, B, C and D. A, C and D were female and B was male.

Some students persisted with an exploratory approach for the entire four sessions. Table 5.36 presents some extracts from the journal of one such student who recorded a total of 8 hours working with the materials. Although this student appears not to have commenced any of the problems, there is a clear progression in her comments from the first session to the last. Her initial reaction to the CD is at best sceptical and almost hostile. By the third session of exploration she had begun to find some value in the materials and her comments for the last session are quite positive.

Table 5.36: Extracts from the journal of student A

Session	Comments
1	Tried to work out the CD and what the purpose of it was.
	The most important thing I learned is that I will have to become a computer wiz to work your program.
	There is so much text to read! Get to the facts.
2	Because there is so much to do (so many things to click into) I had to just look at everything still.
	When you click on the computer you end up at a window with a huge amount of things to look at. I will need a lot of time to go through all of this.
3	Looked at the different videos and looked in 'highlighted' text. Read a lot of text.
	Looking at the teachers (eg Karen) and seeing how technology works for them gave me some hints as to what I might do when teaching.
	It was informative this time but again a lot to read. That's OK though as it answers most of your questions for you.
4	Looked and listened to each teacher's methods and views on IT. I examined the different styles of teaching.
	Probably gave me a more rounded outlook on teaching IT. I have learned some new and interesting ways to teach IT and also how to get the most out of using computers in the classroom. Neil was a bit old fashioned.
	It is a very interesting CD and with more time I shall explore its entire contents.

Most students appeared to have moved directly into the scenarios but their approaches varied. Some took four sessions to work through a single problem. Others pushed through more quickly, attempting a different scenario in each session. Table 5.37 presents extracts from the journal of a student who spent the four sessions (recorded as a total of 5 hours) working through the first scenario. Although technical problems were encountered in the second session, there is no indication that they were the cause of the student working with just one scenario throughout all four sessions.

Table 5.37: Extracts from the journal of student B

Session	Comments
1	After a general look around I started a more in depth look at the task areas … I applied for the first job and was accepted. I also looked at the other teachers' applications for comparison.
	My initial reaction to the CD is that it should be a useful learning tool.
2	Little was accomplished as I was having trouble with the CD and the computer.
3	Completed the bulk of the first scenario up to designing the classroom.
	I thought the classroom design was an excellent section - very practical.
4	Finished completely task 1.
	In real life situations it highlighted the benefits of consultation and networking with others.
	The session showed a staff meeting. This highlights how important it is to be able to discuss problems and ideas with colleagues.

By way of contrast, Table 5.38 presents extracts from the journal of a student who reported a total of 4.5 hours working with the materials across all four scenarios. It is interesting to note that certain elements of content, such as the folders and video, were not discovered until the student was working on the second or third scenario. The comments suggest that, despite what might be interpreted as a superficial engagement with the materials, the student has acquired fresh insights about teaching with technology.

Table 5.38: Extracts from the journal of student C

Session	Comments
1	Worked through the first session, job application letter, staff meeting, arrange room. Skipped through quickly.
	I realised how much I need to catch up since doing uni part time. How important it is for schools to learn about available technologies and adopt them through the school. The interview with Julie was great - helpful to have an actual insight on the use of technology.
2	Session 2 - Nelson Camp. Answered the selection criteria and provided a sample lesson plan. I also discovered the background info about the teachers - very interesting.
	A teacher's job is never done. Continually involved in planning and organising.
	I am not feeling confident in my ability to prepare as a teacher (or to plan and organise a classroom).
	These scenarios really make you think about the <u>process</u> of teaching.
3	Problem Three - Woigul Woigul School. Prepared the response for the criterion question in relation to technology. Also discovered the folders and video sections - very interesting.
	Planning is everything. Organisation is the key to success.
	The activities are quite detailed. More time is needed to pay attention to the CD-ROM. My initial reaction to this was that I thought it was <u>only</u> selection criteria.
4	Session 4. Problem with program reported. Flicked through the session but haven't completed it as yet.
	I know very little of preparing a website. This is a definite learning curve.
	My head is swimming. Where do I start for a website?

The final set of extracts presented in Table 5.39 were written by a student who spent 6 hours to complete the first scenario and begin the second one. The comments provide clear evidence that the materials have challenged the student's thinking in several areas.

Table 5.39: Extracts from the journal of student D

Session	Comments
1	Getting started, … having a look around.
	I need more experience in classrooms to even understand the problems posed in these scenarios.
	I felt overwhelmed by my feelings of inadequacy. How do I write criteria for job applications? My classroom experience is limited.
2	The first problem.
	Teachers are working hard to fully integrate computers and other technology into their curriculum.
	This challenged my knowledge bank, problem solving skills, analytical thinking. I thought "this is good for me as it contains extremely useful information". This will be a great resource.
3	The first school again.
	Writing to the selection criteria and writing other information the principal required from me as a "teacher". Even though there is lots of information on the CD I felt I needed to research the answers.
	It challenged my thinking and opinions on classroom management, teaching styles, equal access, usefulness of computers.
4	The second problem.
	I used and relied on information learned in the first exercise/problem. This was more challenging than the first.
	I love the little videos and interviews. I think the help and hints for writing the criteria responses are very appropriate and useful.

Overall the data from the journals reinforce those obtained from the evaluation questionnaire. Elements of the IMM-PBL materials that have made the strongest impression appear to have been the video interviews with the consultants and the activation tasks based on applying for teaching positions. Even students who were initially unenthusiastic found value in the materials if they persisted.

5.5.3.3 Participant interviews

As described in Chapter 3, four participants in the evaluation responded to an open invitation to all participants to engage in a brief interview. Thus the interviewees were self-selected and might be presumed to have stronger than typical opinions about the experience. The interviews were conducted using the questions listed in Table 3.14 and the audio recordings were subsequently transcribed.

The transcripts of the four interviews were read with a view to obtaining an understanding of participants' responses to the materials. For convenience the four participants are referred to as E, F, G and H to distinguish them from those referred to in the account of the journal entries. E, F and G were female and H was male. None of them was included among those (A, B, C and D) whose journals were quoted in the previous section.

Participants' strongest memories of the materials varied. Participant E spoke about the frustration experienced while working with the materials and attributed that to personal "incompetence". Journal entries confirmed that this participant was an inexperienced computer user whose difficulties were compounded by the technical issues in the laboratory.

Participant F referred to the opportunities to compare personal responses to tasks with those from the consultants. G "loved the videos and the interactive stuff" and H recalled the "practical application of it" including writing job applications, responses from the consultants and the interviews with the consultants.

All four were able to recall some details of the scenarios they worked through but the level of detail varied. Only F was able to recount the approximate sequence of activities in a particular scenario. For E that was certainly a consequence of not having advanced beyond the beginning of any of the scenarios but, for G, two scenarios appeared to have merged in memory and she could not recall details of either one.

In response to the question about what they had learned from the materials, E and F referred to the selection criteria and learning how to respond to them. G commented that "you don't need to be a computer wiz to integrate it into a classroom and it's not hard to do". H said

> it's helped me to just, from those interviews from the video sequence, it's really given me a bit of enthusiasm …, a bit of excitement to see computing technology can be used in a real and practical way … it's given me a bit of confidence, coming from a position where I knew nothing about computers.

Questions about the importance of details in scenarios, identification with the problems, relevance to teachers' work and the inclusion of participant details in the materials were intended to probe participants' responses to the realism of the materials.

E thought that the problems were realistic, that the inclusion of details "made it realistic so you actually think you're doing it", and that having a personal name appear in the materials "makes it come alive for you, it's not just a problem in a book".

F thought that the problems were all relevant in some way but that the inclusion of details in the scenarios was not "really relevant at all … it didn't matter where it was situated." She subsequently added that "if you had more time, I think then those details would come into effect more, like what you were doing would relate more to particular children". She agreed that the inclusion of the user's name "was good and it, like, made it more personal."

G thought that the names of people in the scenarios were not important but that the detail of the schools was. She thought that the presence of "real teachers there in the videos" added to the sense of relevance and that having her own name appear in the materials "was pretty fun, 'cause it made it more realistic."

For H, the detail in the scenarios was "very important because it adds that dimension of reality" and the problems were "relevant because they are real life experiences how these teachers utilised computers", a reference to the video of the consultants. He thought that the inclusion of the user's name in the materials "created (a) sense of ownership." The IMM-PBL materials were "the only experience I've had with computing in that sense, I haven't seen computers positively in the classroom setting in any of the school work that I've had in the two prac experiences."

Additional remarks in relation to the final invitation to offer other comments ranged wide. E thought the materials were "a worthwhile thing to have for a person working towards their selection criteria." F commented on the difficulty of finding sufficient time to work through the materials thoroughly. G thought the activities "worthwhile for teachers to do and even for uni students because … it gives you an imaginary situation to work in. … I enjoyed it. It was fun." H suggested that "this type of subject should be a core subject where you're looking at saying how can I use computing and multimedia technology and integrate that into curriculum areas."

5.6 Summary of the data

The data collected in the course of this study varied considerably in type and intended purpose. In summary, the data sources were:

- A questionnaire completed by experienced PBL practitioners provided data relevant to the incorporation of PBL principles in the completed IMM-PBL materials.
- Analysis of the interviews with teacher consultants from the IMM-PBL materials provided a basis for comparing the content of those interviews with the literature about computer-using teachers and for probing the knowledge of participants in the evaluation trial.
- Questionnaires administered to participants in the trial of the software prototype provided data for a pilot study of the instruments to be used in the final evaluation and responses on which to base the refinement of the materials design.
- An heuristic evaluation conducted for the beta version of the IMM-PBL materials provided data on which to base modifications to the design of the completed version.
- Instruments administered to a final year teacher education class provided data for examining the relationships among self-efficacy for teaching with computers and other variables.
- Instruments administered to experimental and control groups provided data relevant to the effects of the IMM-PBL materials on self-efficacy for teaching with computers and other variables.
- Additional data, collected by questionnaires, journals and interviews with the experimental group, provided a basis for evaluating the user response to the IMM-PBL materials.

Chapter 6 will discuss the implications of the data in relation to the research questions proposed in Chapter 3.

Chapter 6: Discussion and conclusions

This study sought to investigate the effects of interactive multimedia, using problem-based learning as the underlying design framework (IMM-PBL), on pre-service teachers' self-efficacy beliefs for teaching with computers. Chapter 3 proposed six research questions to guide the investigation and described the methods that would be used to collect and analyse data.

This chapter begins with a brief discussion of how each of the IMM-PBL design principles outlined in Chapter 2 has been applied in this project. It will then consider what answers to the research questions may be found from the data presented in Chapter 5. Each question will be considered in turn. That will be followed by conclusions and recommendations for further development and associated research.

6.1 Applying the IMM-PBL design principles

An investigation of the effects of IMM-PBL would not be possible in the absence of an example of IMM-PBL. Hence, a significant part of this project entailed the design and development of IMM-PBL with content appropriate to enhancing pre-service teachers' self-efficacy beliefs for teaching with computers. Chapter 2 concluded by synthesising the relevant research into a statement of nine principles for the design of IMM-PBL. These principles were used as the basis for the design and development of *Integrating Information Technology into Teaching* (Gibson & Albion, 1999). This section will discuss the way in which the design of those materials addresses each of the principles, in the light of the design and development process as described in Chapter 4 and data presented in Chapter 5.

Principle 1: Begin with an authentic problem

Each of the four scenarios included in the IMM-PBL materials is located in the general context of a teacher applying for a temporary teaching position, which provides the context for dealing with a series of tasks related to technology integration. Stimulus materials such as the advertisements, correspondence from the schools, school documents and other details of the schools were carefully selected or created to be as convincing as possible. All problem outlines and the associated stimulus materials were reviewed for plausibility by several qualified and experienced teachers, namely the developers, research assistants and the co-operating teachers. Care was taken to ensure that the tasks to be presented had relevance in the real world of teaching and a logical purpose in the context of the scenarios.

Responses to the relevant item on the questionnaire directed to PBL practitioners recorded a median rating of 4.50 (on a 5-point scale), indicating strong agreement that the IMM-PBL materials begin by presenting a problem. The beta test reviewers recorded median ratings of 5.0 (on a 5-point scale) for the establishment of context and the relevance of the scenarios. Students participating in the evaluation of the completed materials also viewed the problems as relevant to their future role as teachers (median = 4.0 on a 5-point scale) and included comments noting the realism of the materials in their written responses. Many of those comments referred to the inclusion of the interviews and other elements provided by the practising teachers and it seems that these components were important for establishing context and relevance.

Thus it seems reasonable to claim that the IMM-PBL materials developed for this study have applied the first of the nine principles for IMM-PBL design. This principle is fundamental to the claim that the IMM-PBL materials are a genuine expression of PBL and should be an important consideration in any future IMM-PBL development. The anticipated benefits of the use of media, including video, audio and photographs, for presentation of problems (Hoffman & Ritchie, 1997) appear to be confirmed and similar uses of media should be considered in future IMM-PBL materials.

Principle 2: Incorporate relevant cases

Each of the scenarios was, in effect, a relevant case for solution by the users of the materials. In addition, the materials included other "cases" for reference. Relevant excerpts from the *Classroom Computing* video (Albion, 1996a) provided interviews with experienced computer-using teachers shown together with activities in their classrooms. Video and transcripts of interviews with seven co-operating teachers talking about their use of computers were incorporated into the scenarios. Permission was obtained from the copyright holders to include a collection of over 40 descriptions of exemplary teacher practice in the use of IT in Australian schools (ACT Department of Education and Training, 1996).

The video clips of the co-operating teachers were the most commonly mentioned feature of the materials in both the prototype trial and the evaluation of the completed materials. Interviews with participants in the evaluation referred to "real teachers there in the video" adding to the relevance of the materials and noted that the videos were "relevant because they are real life experiences of how these teachers used computers." The relevance of the content is apparent to the target audience and to the beta evaluators as noted previously.

There is also evidence, in the responses from the participants in the final evaluation about what they had learned, that the video was effective as a means of communicating significant ideas about teaching with computers. It is less clear from the data whether the other case material included in the package had an appreciable effect on the users. It may be that, in the relatively short time available for interaction with the materials, few users explored far beyond the most obvious components. Certainly the elements that were perceived by users as being "real" were effective and support the validity of the second principle for IMM-PBL.

User reaction to the video interviews in both the prototype and completed versions of the IMM-PBL materials confirmed the capacity of media-enriched case materials to engage users' attention. Hence the use of media, especially video, as an effective means of presenting cases is also supported.

Principle 3: Represent multiple viewpoints

The seven co-operating teachers were invited with a view to providing different perspectives on the use of IT in teaching. In addition to the different points of view expressed in their interviews, they were engaged to create sample responses to each of the tasks embedded in the scenarios. Thus users were provided with several alternative sample responses to each task as they completed it.

Responses from participants in the evaluation of the completed IMM-PBL materials referred to the materials enabling them to "see how other teachers operate, solve problems and integrate computer technology" and to the inclusion of "alternate responses to the same questions - different doesn't mean wrong." Others mentioned how their ideas about the use of computers had been changed or challenged by their encounters with different viewpoints in the materials. There were no suggestions, in any of the participants' responses, that the juxtaposition of alternative points of view had resulted in confusion or that they would have preferred a single "correct" answer to any of the tasks.

Users' ready acceptance of alternative views and the revision of some personal positions as a consequence of working with the materials lend support to the third principle of including multiple viewpoints in IMM-PBL materials. The use of sample responses to tasks prepared from different perspectives appears to be an effective means of presenting alternative viewpoints.

Principle 4: Stimulate activation and elaboration of knowledge

Each of the four scenarios was introduced with a task in which the user was invited to respond to a selection criterion for the advertised position around which the scenario was based. The selection criterion for each scenario was constructed to elicit responses based on knowledge that was considered directly relevant to the issues around which the corresponding scenario was built, thereby ensuring that users would have opportunity to activate prior knowledge prior to dealing with the issues in the scenario.

The subsequent tasks in each scenario were structured to encourage the user to elaborate knowledge that they had brought with them to the materials or had acquired while working in the scenario. The form of elaboration varied from preparing a plan for locating equipment in a classroom, through preparing outlines of plans for teaching and preparing summaries of ideas presented in the materials.

Responses to the PBL practitioner questionnaire recognised the presence of opportunities for activation (median = 5.0) and elaboration (median = 4.0) of knowledge. Several of the comments in participant's journals indicated that the materials had encouraged a reappraisal of existing knowledge. Participant C "realised how much (she) need(ed) to catch up" and participant D "felt overwhelmed by (her) feelings of inadequacy" in relation to writing to criteria for employment. Several participants mentioned their engagement with writing to the criteria and other tasks that would have involved them in activating and elaborating knowledge.

Decomposition of each problem-based scenario into a series of tasks, which were designed to encourage activation and elaboration (Albion & Gibson, 1998a), appears to have been an effective method of encouraging users to access and review their existing knowledge. Although writing to selection criteria had been conceived of as a relevant task for pre-service teachers in their final year, its popularity with participants in the final evaluation appears to have resulted from introduction of the idea in other contexts. It was a double-edged sword inasmuch as it encouraged students to engage with that portion of the materials but appears to have distracted some students from exploring other aspects of the package. One of the PBL practitioners noted that the similarities among the four scenarios could lead to their becoming routine. Although future IMM-PBL materials would benefit from decomposing problems into tasks to encourage activation and elaboration, the addition of other contexts for the initial task would lend variety and assist in maintaining user interest.

Principle 5: Scaffold learner performance

The primary form of scaffolding offered in the materials is the decomposition of the problems into sub-problems or tasks (Savery & Duffy, 1995). Additional scaffolding is provided in the form of detailed contextual help which, at each point where the user is required to perform, describes the steps to be undertaken and offers links to relevant resources within the materials and on the Internet.

Reviewers of the beta version gave a median rating of 4.5 to the scaffolding of activities in the materials. Where participants in the final evaluation commented on the help system, it was in terms such as: "I think the help and hints for writing the criteria responses are very appropriate and helpful." One student suggested that users should have access to sample responses before producing their own, implying that the sample responses were helpful in scaffolding performance. One of the PBL practitioners commented on the scaffolding, although none of the items referred to it, suggesting that the scaffolding might limit the degree of elaboration of ideas by users.

Scaffolding in conventional PBL is provided by the tutor (Boud, 1985; Savery & Duffy, 1995; Schmidt & Moust, 1998), who is able to adjust the guidance or assistance offered to suit the circumstances. By comparison, the scaffolding in the current version of the IMM-PBL materials is inflexible, being limited to predefined decomposition of the problem into tasks or access to the help system. The latter, though contextual, always offers the same help for a particular location regardless of the specific needs of the user. These mechanisms are better than nothing, but future developers of IMM-PBL could usefully investigate the possibilities for creating scaffolding systems that are more responsive to the individual needs of the user. Models do exist in the "guides" or "assistants" provided in some modern software, but the necessary programming was beyond the limited resources of the current project.

Principle 6: Provide a strong narrative line

Each of the four scenarios provides for the user to progress through a series of episodes in a story. The scenarios have an overall similarity to each other that should assist with patterning for the user, but include sufficient variation to maintain interest. In a manner reminiscent of early movies (Plowman, 1994), screens between key points in each scenario display short segments of text, *intertitles*, which describe some of the story. Names and other details of characters in the scenarios are provided along with photographs of locations and appropriate sound effects to provide an appropriate sense of simulated reality. The name of the user appears in appropriate places in correspondence and other parts of the materials.

An open-ended question on the evaluation questionnaire asked participants to describe the materials to a colleague. Some of the responses outlined the sequence of tasks in the scenario and one referred explicitly to role-playing, but none recounted the story associated with the scenario. Participants who were interviewed differed in respect of the importance they placed on details in the scenarios but all seemed to agree that inclusion of the user's name made the experience more personal. Based on the evidence from the participant journals, it seems possible that relatively few users in the evaluation trial progressed far enough into any of the scenarios to develop a strong sense of the narrative. The limited class time available during the trial was expected to impose some limits on participants' interaction with the materials but the technical difficulties in the laboratory and users' unanticipated focus on writing to selection criteria further reduced the time available for sustained interaction with the materials. Many users appear to have spent a large proportion of their time exploring the resources and some worked with the initial part of each scenario rather than all the way through one scenario.

The narrative might become more evident to users if they spent more time in a single scenario. Making additional time available for each scenario or structuring class activities which depend upon and support sustained interaction with the materials might encourage students to spend more time engaging with the scenario. Future investigations of the use of the IMM-PBL materials under different conditions might increase understanding of the role, if any, played by narrative in influencing changes in users' knowledge and beliefs during interaction with IMM-PBL.

Principle 7: Provide access to relevant information

In addition to the content described above in the reference to cases, the package includes a substantial collection of materials reproduced with permission from web sites created by the Open Learning Technology Corporation (Open Learning Technology Corporation, 1995, 1996a, b). Together these sites constitute over 100 pages of material related to learning theories and the educational applications of information technology. The approach adopted to including resources has been described thus:

> Because PBL is intended to increase the capacity of learners to solve real problems (Boud, 1985) and because identifying critical elements may be

> counter-productive (Savery & Duffy, 1995), the selection of resources for inclusion in the package is gauged to require judgement in selection from what is provided and initiative in employing material from alternative sources. (Albion & Gibson, 1998a)

The beta reviewers gave median ratings of 5.0 each for presentation of resources, relevance of reference materials and presentation of video resources. These data suggest that there was little room for improvement in these aspects of the materials at the beta stage and there is no indication that the completed version of the materials was less effective in respect of these aspects.

Participants in the evaluation appeared to concentrate on the video interviews and sample responses generated by the consultants. There is no indication of the extent to which they engaged with the embedded reference materials. It is possible that the limited time available to participants in the laboratory sessions encouraged them to concentrate on the more obvious resources and restricted their exploration of the other materials. Users indicated that they found the materials they encountered useful and that may have reduced their need to explore more widely in the limited time available. Additional investigation of users' interaction with IMM-PBL with less restriction on available time might reveal different patterns in respect of accessing resources.

Principle 8: Encourage self-evaluation

Self-evaluation while using the IMM-PBL materials is encouraged by providing solutions with which users may compare their own responses. Offering worthwhile feedback on responses is one of the challenges to be faced in developing IMM dealing with ill-structured problems such as those that occur in teaching (Gibson & Albion, 1997). Jonassen (1997, p. 85) suggested that "it is important that learners be able to articulate the differing assumptions in support of arguments for whatever solution they recommend."

In these materials, each time users complete a task they are able to compare their response with those offered by the co-operating teachers. Although the materials are not able to offer any judgement of the user's response, they include a summary of key points from the sample responses and, in some cases, additional commentary.

Comments made by participants in the evaluation trials, in their journals or elsewhere, indicated that the sample responses challenged their thinking and provided them with new ideas. Several identified specific changes in their thinking about teaching with computers as a result of using the materials. These data suggest that the materials are encouraging users to engage in self-evaluation.

The beta reviewers gave formative evaluation a median rating of 4.0. Their comments noted that feedback was limited to the opportunity to compare responses with the samples provided by the consultants and that some form of judging of users' responses, or even the addition of evaluative comments about the responses, might assist. The meta-responses, which were subsequently introduced to assist users in dealing with the large volume of text in the sample responses (Albion, 1999c), should serve to make the content of the sample responses more accessible to users. Software capable of effectively judging and responding to open-ended text responses would not be easily developed. However, in future developments of IMM-PBL, consideration might be given to a more limited judging system, which could scan a text and provide prompts or responses based on the presence or absence of particular keywords.

Principle 9: Support individual and collaborative learning

Research suggests that one of the key benefits of interaction of groups of learners in PBL is the stimulus to conceptual change that comes from exposure to different ideas (De Grave et al., 1996). The materials include interviews with, and sample responses prepared by, co-operating teachers with differing experiences and approaches to their use of IT in teaching. Exposure to these elements is intended to provide students with opportunities to reassess their own positions on relevant issues.

The beta reviewers gave a median rating of 5.0 for support for collaborative learning and the PBL practitioners gave a median rating of 4.0 for the item about consistency with small group learning. Both groups offered similar comments relating to the possibility of "virtual" interaction with the consultants but the absence of explicit support for interaction with other users. Students who participated in the evaluation did not specifically mention collaboration although it is likely that they interacted with peers in the laboratory.

No specific provision is made to support collaborative learning with these IMM-PBL materials. Where the materials are used by classes there would be value in having groups of students share their responses to the materials. The use of email or other forms of computer mediated communication would allow for group interaction in response to the materials even where students are geographically separated. These modifications could be considered in a future revision.

6.2 Answering the research questions

The collection and analysis of data in this study was guided by the six research questions developed in Chapter 3. In this section, the data presented in Chapter 5 will be applied to answering each of those questions in turn .

6.2.1 Research question 1

How do the views of teaching with ICTs as presented in the IMM-PBL materials compare with the findings of research on teaching with ICTs?

The source of evidence in respect of this question was the analysis of the interviews conducted with the teacher consultants for inclusion in the IMM-PBL materials and comparison with the findings of the research as reviewed in Chapter 2.

That research (see 2.1.3 for a summary) revealed that exemplary computer-using teachers were **predominantly experienced males** who had **taken 3 to 5 years and considerable personal effort to develop their successful approaches** to integrating computers (Becker, 1994; Hadley & Sheingold, 1993; Sherwood, 1993). They tended to have **de-emphasised teacher-centred activity** in their classrooms in favour of more student-centred approaches consistent with constructivist theories of education (Becker, 1994; Hadley & Sheingold, 1993; Honey & Moeller, 1990; Newhouse, 1998, 1999; Sandholtz et al., 1994; Sherwood, 1993). In some cases the evidence suggested that the teachers' **use of computers was consistent with their prior beliefs about teaching** (Honey & Moeller, 1990; MacArthur & Malouf, 1991; Miller & Olson, 1994) but in others it seemed that the **use of computers had resulted in changed approaches to teaching** (Hadley & Sheingold, 1993; Sandholtz et al., 1994; Sherwood, 1993). According to the research, computer-using teachers had been **influenced in their use of computers for teaching by their own sense of competence in using computers** (Marcinkiewicz & Grabowski, 1992) and their **work environment, including peers and supervisors** (Albion, 1996b; Becker, 1994; Hadley & Sheingold, 1993; Sherwood, 1993; Trushell et al., 1998).

The teachers who collaborated in this project as consultants were not selected randomly or as a representative group and it could not be expected that they would match the gender or experience distributions found among the computer-using teachers in larger studies. Julie, Robyn and Neil were clearly not typical of computer-using teachers as described above. Julie, a computer-using teacher, was invited to join the project precisely because, as a female beginning teacher, she would provide a valuable role model for students. Robyn's pre-service preparation had a particular focus on computer use in teaching. Neil was nominated by his principal and was accepted into the project as an experienced teacher who was making an effort to use computers although with some differences from the other teachers. As student A noted in her journal, "Neil was a bit old fashioned." The other consultants, Carla, Karen, Ken and Matt, were probably more typical of computer-using teachers in respect of their teaching experience and development in the use of ICTs.

All of the consultants mentioned multiple ways in which they had used personal time and effort to develop their capabilities for teaching with computers. That the interview fragments coded as *development* accounted for the greatest number of fragments in a single category is a clear indication of the importance the consultants gave to continued professional learning. That category also had the greatest number of sub-categories, indicating openness to a variety of sources. Experience gained through time spent practising with computers and networking with colleagues together accounted for more than half of the fragments in the *development* category. Both of these groups of activities typically depend upon personal commitment rather than provision by an employer or other organisation. In this respect, the teachers who cooperated in the project matched the profile of computer-using teachers as described above.

In the method category there was a strong emphasis on teaching *with*, rather than *about*, ICTs. Ken spoke about how the use of computers had increased the enthusiasm of children for their work. Julie, Matt, Neil and Robyn spoke about the integration of ICTs to support the curriculum rather than as either an addendum or a central focus. Student-centred approaches, involving multiple simultaneous activities in the classroom, were advocated by Julie, Karen and Matt. Julie sought activities where the children "weren't all needing a computer at once" and Matt set up equipment so that he could monitor the work of multiple groups. Robyn advised the use of open-ended projects to enable children to extend an activity. As a beginning teacher, Julie struggled with finding the appropriate balance between individual or small group work and whole of class activities. Carla was working as a specialist teacher of computing, with groups of up to thirty children in a laboratory with ten computers. As a consequence, she adopted a highly structured approach to classes with a focus on incremental development of skills. Other than Carla, whose teaching environment was not a typical classroom, all of the consultants appeared to match, at least to some degree, the tendency among computer-using teachers to de-emphasise teacher-centred approaches in favour of more student-centred approaches.

In general the consultants appeared to have moved beyond a view of "teaching as telling" and to have accepted that one of their roles as teachers was to model the processes of lifelong learning, welcoming opportunities to learn with or from the children. They tended to favour student-centred approaches in class and to provide opportunities for constructivist learning. They have a strong commitment to ongoing professional development, a sense of their own capacity to learn from experience with ICTs and a belief in the value of networking with their peers. In these respects they appear to be similar to computer-using teachers described in other research.

The manner in which these teachers were recruited to the project may have ensured some degree of commonality in their thinking. Four (Carla, Ken, Matt and Robyn) were presenters at a local conference, Karen and Neil were in the same school as Ken and Julie was a beginning teacher with a known commitment to using computers in her teaching. Nevertheless, they are not clones of each other or of some archetypal "computer-using teacher". Some of the differences among them are substantial. Neil has years of teaching experience but is somewhat diffident about working with computers. Julie is just beginning her teaching career and is challenged by classroom management but is committed to integrating computers. Carla has adopted a highly structured approach as a means of managing limited resources and works with other teachers to ensure integration of computers and curriculum. What unites them is their commitment to using computers creatively to improve educational opportunities for students.

Hence, the answer to the first research question is that the views of teaching with ICTs as presented in the IMM-PBL materials are generally consistent with research findings about teaching with ICTs. The messages include the importance of ongoing teacher development especially through peer support networks, the value of student-centred approaches and integration of ICTs with the curriculum, and the certainty that there is no single correct answer to integrating ICTs into teaching.

6.2.2 Research question 2

How well do the IMM-PBL materials incorporate the characteristics of problem-based learning?

The evidence in respect of this question is based on the data collected using the questionnaire addressed to a panel of practitioners on PBL. Although a panel of six might not be sufficient to sustain claims of statistical significance, it exceeds the minimum size recommended for panels of evaluators in heuristic evaluation methods (Nielsen, 1994; Quinn, 1996). That recommendation was based on research on usability inspection of software, which found that a panel of 4 to 6 suitably qualified evaluators would detect essentially all serious interface flaws (Nielsen, 1994). The method used in the questionnaire about PBL characteristics was an inspection method similar in style to the heuristic evaluation employed in the beta testing. Thus, provided that the members were suitably qualified, a panel of six should provide a reliable indication of whether the IMM-PBL materials matched the PBL characteristics identified in the questionnaire.

Based on the reported levels of PBL experience, the panel members have high credibility in the field and should be capable of making appropriate judgements about implementation of PBL principles. The principles (or heuristics) as listed in the questionnaire were based on appropriate sources and their validity was not questioned by the expert panel. Inspection of the pattern of responses revealed that the raters generally agreed that the IMM-PBL materials implemented the PBL principles. The only questionnaire item to attract any level of disagreement about implementation of the relevant principle was item 9. It referred to learning in small groups rather than through lectures and attracted several comments related to the common use of groups in PBL.

As noted in Chapter 5, the additional comments offered by the raters did not contradict the general agreement found in the ratings. However, they did offer several suggestions for improvement, some of which might be implemented by adapting the context in which the materials are used, while others could be incorporated in future IMM-PBL developments.

The most consistent message in the comments related to the absence of group interaction, which is an integral component of conventional PBL. The design of the IMM-PBL materials had attempted to address the impact of group interaction through the inclusion of multiple points of view within the materials, especially in the sample responses offered as feedback for the various tasks (Albion & Gibson, 1998c). However, the introduction to the materials also acknowledged that there would be additional benefit to be gained by working with the materials in collaborative groups. Where IMM-PBL is used in the context of a face to face class, it would be relatively simple to add group interaction about the problems to the class activities. For distance education offerings, group interactions by telephone or e-mail could be introduced. Future versions of IMM-PBL could include direct links to online forums for discussion at key points.

A second set of comments identified a need for the generic feedback offered through sample responses to be supplemented by individual feedback from experienced practitioners. Again, where IMM-PBL is used in conjunction with a class (face to face or distance), class activities could be adjusted to provide for individual feedback by a tutor at key points. As discussed above, a future version of IMM-PBL might include software to scan user submissions for keywords and respond accordingly, to provide some degree of automated individual feedback.

The group of PBL practitioners was small but well qualified by experience for the rating task. Their responses on the rating scales were restricted to "Agree" and "Strongly Agree" on all but three of the nine items. One of those was the item about relevance to teaching where one panelist selected the neutral response and typical comments observed that panel members lacked direct experience of teaching as a basis for rating. The second such item was about consistency of the IMM-PBL materials with knowledge being organised around problems. Of five ratings recorded (one did not rate the item), four selected "Strongly Agree" and the remaining one selected the neutral response. Item 9, which referred to learning in small groups, was the third of these three items. The implications of the ratings on that item have been discussed above.

Overall, there appeared to be consensus from the panel that the IMM-PBL materials match the listed characteristics of PBL derived from the literature and no suggestion that the principles were either incomplete or inappropriate. Thus, subject to the possibilities for future improvement in implementation and design as discussed above, the answer to the second research question is that the IMM-PBL materials have succeeded in incorporating the characteristics of PBL.

6.2.3 Research question 3

How do users react to the presentation and content of the IMM-PBL materials?

There are multiple sources of data relevant to this question. Participants in the trials of the prototype and final versions of the IMM-PBL package responded to questionnaires that included both Likert scale and open-ended items. Panels of reviewers provided ratings of the beta version and of the implementation of PBL in the final version. In addition there were journals maintained by the participants in the evaluation and a small number of interviews conducted with participants. Examination of the data will begin by considering the overall response, followed by more specific consideration of presentation and content.

In respect of the general response, with few exceptions, user responses to the IMM-PBL materials were strongly positive. The 20-item 5-point Likert scales on the user evaluation questionnaires used at the prototype and evaluation stages returned mean ratings of 3.61 and 3.77 respectively. These results are not directly comparable because some of the items were changed from one trial to the second but they do indicate a generally positive response to the aspects of the materials reflected in the scales. Specific aspects of the responses on these scales are discussed below.

Comments recorded on the various questionnaires provide further evidence of positive user response. One of the PBL practitioners commented: "I find your approach refreshing … and one of the best examples I have seen presented online." One participant in the evaluation suggested that a subject using IMM such as that in the evaluation should be a core component of the degree. The merit of this proposition had been recognised previously and a recent program review incorporated a core subject based on the elective subject within which the evaluation trial was located.

Data about the user response to presentation of the IMM-PBL may be found in the beta test responses and in the material obtained in the final evaluation.

On the interface design heuristics of the beta test questionnaire, the mean item score was 4.46, indicating a high level of agreement that it matched the design heuristics. Seven of the ten heuristics attracted median ratings of 5.0, suggesting that there was little perceived need for improvement. The remaining three had median ratings of 4.0. One of those three referred to flexibility and efficiency of use, related to shortcuts and adjusting settings. The materials offered no shortcuts and no adjustment of settings other than those in the standard browser and neither was a necessary addition to the interface. The second item referred to user control and freedom, related to exiting locations and undoing mistakes. Revisions made after the beta test included making some aspects of navigation clearer and giving users more options to go back a step if they found they had moved on too quickly. The third item referred to preventing errors, related to providing guidance to prevent user errors. Revisions made after the beta test included additions and improvements to the help system.

The mean item score on the educational design heuristics in the beta test questionnaire was 4.29. Four of the nine heuristics had median ratings of 5.0 and another (about scaffolding which has been discussed previously) scored 4.5. The remaining four heuristics had median ratings of 4.0. One related to clarity of goals and objectives. The introductory material was revised to clarify goals in the final version and some of the commentary about sample responses was also revised to make relevant aspects more explicit. A second item related to issues such as ability to access information while engaged in an activity. In the final version of the materials a button to make access to the information in the "folders" area was included as a standard part of the interface. The remaining two items referred to aspects of evaluation of users' work. Issues associated with evaluation have been discussed above.

Overall, the beta reviewers found little seriously wrong with the presentation of the materials. The most serious issues they identified were addressed in the preparation of the final version.

The Likert scales in the user evaluation questionnaire administered with the evaluation trials included several items related to presentation. Users agreed that the presentation of sound, video and text were of high quality, that the operating instructions were sufficient, that the materials were easy to use and that the visual design was attractive and functional. These five items had a mean rating of 4.03, indicating a general level of approval. Users expressed some reservations about the adequacy of the feedback provided. Possible improvements in this regard have been discussed above.

Sixteen of 23 responses to an open ended question about first impressions of the materials were positive, offering comments such as "well presented" and "professional". Of sixteen responses to the item about how the package might be improved, none referred to presentation as an aspect requiring improvement. The positive response to presentation of the material was supported in participants' journal entries and in the interviews. The use of video, especially the interviews with teachers, was a popular element of the materials. Future extensions of the materials or development of similar materials might consider including video of additional teachers or extending the range of questions asked in interviews to provide additional contextual detail for learners.

Data about user responses to the content of the materials were obtained in the beta test and in the final evaluation.

On the content design heuristics of the beta test questionnaire, the mean item score was 4.52, indicating a high degree of acceptance that the materials matched the heuristics. Numerous positive comments were offered about the relevance of the content in the package.

Participants in the evaluation trial were mostly enthusiastic about the quality and relevance of the content. They agreed that the problems were relevant to the work of teachers and progressed in a logical manner. They also identified a variety of aspects of teaching for which the materials had offered them some new insight. Their responses to the open ended items were also strong on the value of the content in the materials.

On the basis of the evidence presented thus far it is reasonable to conclude that both the presentation and content of the IMM-PBL materials were well received by the users. Working with the materials appears to have been both enjoyable and educative.

Data collected from the participants' journals and the interviews support this conclusion and add some insights about the ways in which participants worked with the materials. Few of the participants appeared to have engaged with the materials in the intended fashion by working through each scenario, completing the tasks as they went. Some spent their time exploring the resources available from the desk. Some worked through just the first task for each scenario and apparently viewed the entire exercise as directed towards dealing with selection criteria. One journal described working through all four scenarios, while others spent the equivalent time to complete just one scenario.

The different approaches adopted by the trial participants were a consequence of the conditions under which the trial was conducted. Class requirements were not restrictive and students were encouraged to explore the materials as they preferred with the only element of accountability being the maintenance of journals. This approach was thought likely to provide a broad range of responses to the materials. Technical difficulties, especially in the first two weeks of laboratory sessions, and students' unanticipated enthusiasm for the selection criterion tasks may have influenced their interactions with the IMM-PBL materials.

It is possibly true that the effects of the IMM-PBL materials on self-efficacy for teaching might be greater if they were used in the manner anticipated by the designers. From this point of view, the alternative approaches adopted by participants may have impacted negatively on the study. From another point of view, the evidence suggests that the materials are capable of flexible use, which broadens their potential application.

Regardless of the approach they took to the IMM-PBL materials, all but one or two users, who reported experiencing significant technical problems, claimed to have learned something of value in the process. The IMM-PBL materials appear to be a flexible learning resource, capable of supporting different styles of use. The variety in usage patterns was not foreseen. It is not clear whether it was influenced by the technical difficulties experienced in the initial weeks of the trial, resulted from a misunderstanding of instructions about how students should work with the materials, or was somehow related to differences in individual preferences for learning.

The disparate patterns of use of the materials in the evaluation trial present some difficulties for the interpretation of the effects of the materials since the treatment experienced by different students varied so much. Data collected from the relatively small group of users in the evaluation were not sufficient for analysis of differential effects arising from different modes of use and the quantitative data obtained from the pretest-posttest may result from significantly different user experiences of the materials. Variations in the effects of the IMM-PBL materials under different patterns of user experience is a potential area for future research which might yield useful insights into how to maximise the educational benefits of such materials.

Despite the differences in user experiences, the conclusion in respect of the third research question is that users responded positively to the IMM-PBL materials, found them enjoyable to work with and effective for learning.

6.2.4 Research question 4

To what extent is pre-service teachers' self-efficacy for teaching with computers associated with other factors such as age, gender, Innovativeness, Pupil Control Ideology, attitudes towards computers, self-efficacy for computer use and self-efficacy for teaching?

The data relevant to this question were obtained from the instruments administered to the large group of final year pre-service teachers prior to the evaluation trials of the IMM-PBL materials. The group was moderately large (N = 178) and there was no reason to believe that it was not representative of final year pre-service teachers at USQ.

No association was found between the age or gender of pre-service teachers and their self-efficacy for teaching with computers as measured by the SE sub-scale of the MUTEBI. SE was very significantly ($p < .001$) correlated with both the comfort/anxiety and usefulness sub-scales of the ACT instrument, the composite SCT measure, Innovativeness, and the external sub-scale of the teacher efficacy instrument (negative correlation). Less significant ($p < .01$) correlations were found between SE and the internal sub-scale of the teacher efficacy instrument and PCI (negative correlation). Backward multiple regression produced a model in which these variables, with the exception of PCI, were retained and accounted for 61% of the total variance in SE.

Of the six variables in the final regression model, the most significant effect was for the comfort/anxiety sub-scale of the ACT. Typical items on that sub-scale included "I feel comfortable about my ability to work with computer technologies" and "I feel at ease learning about computer technologies." It is not difficult to see how the construct measured by these items might be related to that measured by the SE sub-scale of the MUTEBI. The SE scale includes items such as "I know the steps necessary to use the computer in an instructional setting" and "I understand computer capabilities well enough to be effective using them in my classroom." It would be surprising if being comfortable about using computers were not associated with, or probably a precondition for, being more confident about using them for teaching. There is a clear implication here for teacher education programs that seek to prepare teachers for teaching with ICTs. Previous research (Albion, in press) found that experience with computers, whether at home or in school, was the principal influence on the level of comfort with computers among pre-service teachers at the commencement of their studies. That study recommended that teacher education courses should be structured so as to encourage pre-service teachers to regard computer use as an integral part of their studies and future profession.

The second strongest predictor of SE in the regression model was the external sub-scale of the teacher efficacy scale. In this instance the association was negative, that is, higher scores on SE were associated with lower scores on the external sub-scale of teacher efficacy. According to Guskey and Passaro (1994), the external factor "relates to perceptions of the influence, power, and impact of elements that lie *outside the classroom* and, hence, may be beyond the direct control of individual teachers" (p. 639). The internal sub-scale of the teacher efficacy scale was also in the final regression model, although it was the weakest predictor of SE remaining in the final model. The internal factor "appears to represent perceptions of *personal* influence, power, and impact in teaching and learning situations" (Guskey & Passaro, 1994, p. 639). Considering both the external and internal factors of teacher efficacy, the implication is that pre-service teachers who attribute less influence to factors external to the classroom and possess perceptions of personal capacity to influence learning outcomes are more likely to have higher self-efficacy for teaching with computers as measured by SE. Stated more simply, the more confident pre-service teachers are about their capacity to teach, the more likely they are to be confident about teaching with computers. This is consistent with previous research which found that a stronger sense of capacity to affect classroom outcomes was associated with higher levels of computer use for teaching (Marcinkiewicz & Wittman, 1995). One implication of this finding is that teacher education programs that include activities designed to increase pre-service teachers' self-efficacy beliefs for teaching should also result in increased self-efficacy for teaching with computers.

The usefulness sub-scale of the ACT was the third strongest predictor in the regression model. Typical items from the usefulness sub-scale of the ACT include "If I can use word-processing software, I will be more productive" and "Computer technologies can be used to assist me in organising my work." In principle, it might be possible to agree with statements such as these and still lack confidence for using computers in the classroom. However, in practice, belief in the usefulness of computers is likely to either result from experience in their use or to encourage such experience. In either case, an increase in confidence for teaching with computers might be a logical consequence. Teacher education programs that encourage frequent and varied use of ICTs to accomplish tasks that pre-service teachers perceive as relevant and important are likely to encourage beliefs in the usefulness of ICTs and may indirectly increase pre-service teachers self-efficacy for teaching with ICTs.

Self-competence for computer use and Innovativeness have been found to predict computer use for teaching (Marcinkiewicz, 1994a). The final regression model obtained in this study included Innovativeness and self-efficacy for computer technologies (SCT) as, respectively, the fifth and sixth strongest predictors of SE. Innovativeness is associated with a positive attitude towards change and it is understandable that higher scores on the Innovativeness scale might be associated with willingness to adopt new approaches to teaching involving ICTs as measured by SE. The association of higher scores on SCT with SE is explicable in terms of teachers with higher levels of self-efficacy for using computers in other settings being more prepared to use them in class. In a period of rapid social change such as the present time, openness to change is an important quality, which should be encouraged in teacher preparation programs. Where they succeed, there may be positive implications for self-efficacy for teaching with ICTs. In previous research (Albion, in press), the only consistent predictor found for higher scores on SCT was greater computer use. Teacher education courses seeking to prepare teachers to teach with ICTs should adopt practices which encourage consistent use of ICTs for relevant tasks.

Pupil Control Ideology (PCI) has been found to be related to science teaching self-efficacy (Enochs et al., 1995) and was negatively correlated with SE in this study ($p < .01$). Higher scores on the PCI scale represent a more custodial orientation. Hence the negative correlation between PCI and SE implies that pre-service teachers with less custodial orientations towards classroom management are more likely to have higher SE. This is consistent with studies that have found use of ICTs in teaching to be associated with more student-centred approaches to management (for example, Honey & Moeller, 1990; Sandholtz et al., 1997). PCI was very significantly correlated ($p < .001$) with usefulness, Innovativeness and the external factor of teacher efficacy, each of which was more strongly correlated with

SE than was PCI. Hence, it was eliminated from the regression analysis model and the other variables were retained.

In response to the fourth research question it may be said that the significant predictors of self-efficacy for teaching with computers are attitudes towards computer technologies (comfort/anxiety and usefulness), self-efficacy for computer technologies, teacher efficacy and Innovativeness. Age, gender and Pupil Control Ideology did not have significant independent power as predictors of self-efficacy for teaching with computers. These findings are consistent with those reported previously (Marcinkiewicz, 1994a; Marcinkiewicz & Wittman, 1995).

There are implications in these relationships for the potential effectiveness of an intervention such as IMM-PBL that seeks to increase users' self-efficacy for teaching with computers. Were SE to be significantly dependent upon one or more factors that would not be affected by the IMM-PBL intervention, then the effectiveness of the IMM-PBL, for at least some users, might be reduced. Among the significant predictors of SE identified above, attitudes towards computer technologies (comfort/anxiety and usefulness) and self-efficacy for computer technologies might be expected to be positively affected by working with IMM-PBL. Inspection of the results obtained for the pretest and posttest administrations of the ACT and SCT reveals that the experimental group recorded increases on all three although only the increase for SCT ($t = 2.08$, $df = 21$, $p = .050$) was statistically significant. These results suggest that the influence of factors measured by the ACT and SCT should not significantly impede the effectiveness of IMM-PBL.

If IMM-PBL is effective in increasing SE then it is possible that it might also influence teacher efficacy through the same mechanism of exposing users to appropriate models and relevant practice. However, no inference can be drawn about this since teacher efficacy was not measured by the posttest in this study. Innovativeness was not measured in the posttest either. However, inasmuch as it is a measure of a broader orientation to change it might be expected to be less susceptible to variation due to a short intervention such as the use of IMM-PBL in this study.

6.2.5 Research question 5

What effect does working with the IMM-PBL materials have on pre-service teachers' perceptions of their knowledge and understanding of using computers in their teaching or of other aspects of teaching?

The data in relation to this question were gathered through the questionnaires, participant journals and interviews associated with the evaluation of the completed IMM-PBL materials.

In general, participants in the evaluation trial appeared to believe that they learned through using the package. Several of the 5-point Likert scale items on the user evaluation questionnaire (Table 5.33) offered statements similar to: "Using this multimedia package helped to improve my knowledge of classroom management." Median ratings of 4.0 were recorded for items indicating agreement that the package had helped participants increase their confidence for making professional decisions (71%), improve their knowledge of classroom management (63%), prepare better for using technology in the classroom (75%), and improve their understanding of integrating technology into teaching (79%). Numbers in parentheses represent the proportion of respondents (N = 24) who indicated agreement or strong agreement with each statement. The remaining respondents in each case selected a neutral response or one indicating (strong) disagreement.

As shown in Table 5.35, a substantial proportion of respondents (N = 24) (shown in parentheses) indicated that working with the materials had enabled them to gain some insight into aspects of teaching. These included such issues as arranging the physical layout of classrooms (75%), teachers' knowledge of technology (75%), classroom management (71%), integrating content (67%) and several others. Four respondents did not select any of the listed issues.

In interpreting these data, it is worth recalling that, according to participants' journal records, the time spent working with the IMM-PBL materials ranged from 2.5 h to 10 h, with a mean of 6.2 h. For respondents at the lower end of the range, there may have been little time to do more than become minimally familiar with the operation of the software. It is also clear from the journals that there was substantial variation in the parts of the materials accessed. Hence, it is understandable that respondents' perceptions of what they learned from the materials also varied.

The data from these scales are clearly subjective since they rely upon respondents' own perceptions of what they learned. Neither is there any indication of the degree of improvement that respondents claimed. Nevertheless, these data do indicate that users of the IMM-PBL materials believe that the materials are effective for learning.

Other data sources, namely the responses to the open-ended questions in the evaluation questionnaire, the participants' journals and interviews, support the view that learning has occurred. Most (71%) of the respondents (N = 24) to the evaluation questionnaire were able to describe at least one "specific aspect of teaching with technology" about which they had learned by working with the IMM-PBL materials. A few wrote comments suggesting that they had experienced significant conceptual changes. More than half (62%) of the responses (N = 21) to a question about the greatest benefit from the IMM-PBL materials referred to the processes of applying for employment but 29% referred to preparation for future teaching, especially in relation to use of IT and thinking like a teacher.

Among the matters that featured in comments from respondents to the questionnaire, journals or interviews were:

- the benefit of directly experiencing a different way of learning;
- the possibility of alternative solutions to teaching problems, as expressed by a respondent who noted that "different doesn't mean wrong";

- a new awareness of the possibilities of using computers other than in "spare time";
- the possible value of computers in subjects other than mathematics;
- the use of computers for teachers' work as well as students' work;
- a "more rounded outlook on teaching IT".

Each of these items represents a significant piece of learning for the pre-service teacher who recorded it.

The only instrument which permitted a direct quantitative measure of changes in the knowledge and understanding of participants in the evaluation trial of the IMM-PBL materials was the set of open ended questions administered in both the pretest and posttest versions of the multi-instrument questionnaire. Those questions were based on the categories that emerged from the analysis of the consultant interview transcripts and the data were analysed by comparing the frequency of statements assigned to each sub-category. The data are reported in Table 5.32. Analysis revealed very few significant differences between experimental (N = 22) and control (N = 27) groups.

There was a significant posttest difference ($p = .003$) in favour of the control group in relation to inservice education as a means of professional development in using computers for teaching. The frequency of responses in that sub-category was constant for the experimental group but increased for the control group. There is no readily apparent explanation for the increase in frequency for the control group.

The remaining significant differences between experimental and control groups on the posttest were for the value of networking with colleagues ($p = .007$) and practical experience with computers ($p = .047$). These ideas were the two most commonly mentioned in the consultant interviews and a simple explanation for the change might be that participants in the trial increased their awareness of these forms of development as a result of working with the IMM-PBL materials.

Thus, although there is little in the way of statistically significant change, the answer to the fifth research question is that participants perceived that working with the IMM-PBL materials increased their knowledge and understanding of the work of teachers and, in particular, of the possibilities for integration of computers into teaching.

6.2.6 Research question 6

What is the effect of IMM-PBL materials on pre-service teachers' self-efficacy beliefs in respect of teaching with computers?

Analysis of the data from the evaluation trials revealed no significant differences between pretest and posttest scores on the self-efficacy (SE) sub-scale of the MUTEBI for either experimental or control groups. Inspection of the data for those who had initially low scores for SE found that the means for both experimental and control group had increased between pretest and posttest. Analysis of the changes revealed a significantly greater increase ($t = 2.71$, $df = 23$, $p = .013$) for the experimental group. This increase was greater than might be expected for statistical regression and appears to be evidence of a small, but significant, change in SE resulting from the use of the IMM-PBL materials.

The absence of a significant change in SE for the experimental group as a whole is a consequence of a decrease in SE scores for the participants in the high SE group. This decrease was sufficient to counter the effect of the increase for the low group and result in a negligible increase for the group as a whole.

The decrease in SE observed for the initially high SE group is consistent with self-efficacy theory, which suggests that self-efficacy beliefs change as a result of new information and may decrease if experience shows that an activity proves more difficult than was previously believed (Bandura, 1986, p. 399). It is possible that students in the initially high SE group had overestimated their capabilities and revised their estimates of their ability on the basis of their experience with the IMM-PBL materials. Equally, participants in the low SE group may have initially underestimated their capabilities or overestimated the difficulties of working with computers.

Statements made by participants in their open ended responses, journals and interviews provide support for the conclusion that some participants experienced an increase in self-efficacy for teaching with computers as a result of working with the IMM-PBL materials. Several students wrote or spoke of increased enthusiasm for using computers or a gain in confidence. One of the interviewees commented that she had learned that "you don't need to be a computer wiz to integrate it in the classroom and it's not hard to do."

The relatively modest increase in SE for the experimental group is probably related to the limited and variable exposure of participants to the IMM-PBL materials. The average time spent working with the materials was about 6 hours and for many participants some part of that time was likely spent in dealing with technical problems that arose in the laboratory environment. Although there is no evidence in support or to the contrary, it seems reasonable to expect that the participants most affected by the technical difficulties might have been those with lower initial scores for variables such as SE, SCT and the comfort/anxiety sub-scale of the ACT. If this were the case, then they would have had reduced time for interaction with the materials and may have had their, already low, self-efficacy for working with computers decreased through failure to succeed in a computer-related activity.

Even when the equipment did not prevent the effective use of the materials, the laboratory configuration did not support the mechanism for enabling users to resume at the location they had exited in the previous session. This may have encouraged participants to begin a fresh scenario each session rather than continue with one they had not completed in the previous session. The consequence of this would have been that some users did not move beyond the initial task in each scenario to engage with the narrative and the more complex tasks, thus limiting the potential impact of the materials on their self-efficacy. Again, it seems likely that those with initially low self-efficacy for working with computers might have been more susceptible to this effect. The tendency to concentrate on the selection criterion tasks may have been increased by the perception among some students that this was the focus of the IMM-PBL materials.

Despite these limitations, however, the final research question can be answered by stating that the use of the IMM-PBL materials resulted in an increase in self-efficacy for teaching with computers for participants with low commencing values of self-efficacy for teaching with computers. Further research on the effects of working with the IMM-PBL materials under more favourable conditions might lead to a more complete understanding of the effectiveness of the materials in the absence of confounding circumstances.

6.3 Conclusions

This study set out to investigate what form of professional education might be effective in preparing pre-service teachers for integrating ICTs into their teaching. A review of relevant literature across several fields identified self-efficacy beliefs about teaching with computers as a potentially important influence on teachers' use of computers in their teaching and suggested that interactive multimedia using a problem-based learning design (IMM-PBL) might prove effective at enhancing self-efficacy beliefs. Principles for the design of IMM-PBL were derived from the literature.

As outlined in Chapter 3, this study comprised two major processes. The first of these was the design and development of interactive multimedia problem-based learning for professional development of teachers in respect of teaching with information and communications technologies. The second was the investigation of the effects of the IMM-PBL materials in use with preservice teachers.

6.3.1 Design and development of IMM-PBL

Design and development of IMM-PBL materials with a focus on the integration of information technology into teaching was guided by the principles derived from the literature. Formative evaluation processes were employed to ensure that the content and presentation of the multimedia materials were suitable for the intended audience. Comparison of the completed IMM-PBL materials with the design principles confirmed that the principles had been consistently applied in the development of this package. Data from the formative and summative evaluations supported this conclusion. Analysis of significant elements of the content in the materials confirmed that the views of computer-using teachers as presented in the materials were consistent with published research about computer-using teachers. Beta evaluation data supported the general soundness of the design in terms of user interface, educational design and content. The legitimacy of the IMM-PBL materials as PBL was confirmed through review by an independent panel of experienced PBL practitioners. End user testing conducted with a prototype and with the completed IMM-PBL package confirmed that, apart from technical difficulties caused by laboratory configuration, users found the materials easy to use and perceived the content as both interesting and relevant to their future careers as teachers.

Hence, it is reasonable to conclude that the first of the two major processes has been successfully completed and that the materials packaged as *Integrating Information Technology into Teaching* are consistent with the principles identified for IMM-PBL design and include content appropriate to their intended purpose and audience.

The IMM-PBL design principles derived from the literature review in Chapter 2 appear to have provided a theoretically sound and practical framework for the design and development of IMM-PBL. Where there are deficiencies in the present design, notably in the provision for individual feedback and for group interaction, there are opportunities for future extension of the design using more sophisticated programming techniques. In the meantime, careful attention to the contexts in which IMM-PBL is used should achieve at least some of the benefits likely from such development.

At least some of the difficulties encountered in the development phase appear to have stemmed from delays in the cycle of revisions associated with the rapid prototyping approach which was adopted for this project (Albion, 1999c). Frequent interaction between designers and programmers is essential to maintain alignment between their expectations of a project and to ensure timely completion.

The formative evaluation processes employed in this study, including the novel use of heuristic methods in the beta trial, were successful in collecting data that guided the refinement of the design. The summative evaluation techniques applied a combination of qualitative and quantitative methods to collect data about the user experience and the effects of the completed materials in use. Interpretation of results from the latter was confounded by unanticipated technical difficulties, and a context that encouraged user initiated exploration of the materials. More direct observation of users interaction with the materials might have helped to clarify the meaning of some of the data which was generated by different patterns of use.

6.3.2 Effects of IMM-PBL

The completed IMM-PBL materials were evaluated in use with a group of pre-service teachers. The effects of the materials on users' knowledge and self-efficacy beliefs about integrating ICTs into teaching were limited by the conditions of use. Time spent working with the materials ranged from 2.5 hours to 10 hours and averaged 6.2 hours. It is difficult to estimate a time for optimal use of the materials. They include over an hour of video clips and the equivalent of at least 200 pages of text. On this basis it might require at least 6 hours to peruse the content without engaging with the tasks embedded in the scenarios. A thorough exploration of the materials and completion of the tasks might require as much as

20 hours. Finding additional class time for students to work with the materials would present difficulties but it would be possible to extend the interaction time by requiring students to undertake preparatory work with the materials between classes.

For many of the participants in the trial, the effectiveness of the time they spent with the materials was further reduced by technical difficulties experienced especially in the initial sessions. Moreover, as revealed by the participants' journals there were some significant variations in the approaches taken to the materials, ranging from simple exploration of resources to thorough engagement with the problem scenarios.

Given these limitations, it is understandable that there were few statistically significant differences between the experimental and control groups in respect of their posttest responses to the open ended questions on the multi-instrument questionnaire. However, participants' responses to the user evaluation questionnaire and data from the journals and interviews indicate that they considered that the materials had assisted them in learning about teaching and especially about the integration of ICTs. Participants also registered significant increases in self-efficacy for computer technologies, specifically on the CD-ROM and Internet sub-scales that were most closely related to the activities in the trial.

As discussed above, participants who had initially low values of SE recorded a significant increase in SE while those who began with higher values of SE recorded a decrease. These changes are consistent with predictions from self-efficacy theory.

In summary, there is evidence that users of the IMM-PBL materials experienced increases in their knowledge of the work of teaching especially as it relates to the use of ICTs and increases in their self-efficacy for the use of computer technologies and for teaching with computers. Hence, it is possible to conclude that the IMM-PBL materials were effective for increasing the knowledge and self-efficacy of preservice teachers in relation to teaching with computers.

Nevertheless, there remains some doubt about the role of the PBL design in the observed effects of the IMM-PBL materials. It is clear from the participants' journals that the manner and extent of their interaction with the materials varied considerably. The implied versatility of the materials for different modes of use may represent a strength since it should encourage their use under different circumstances. However, in the context of this study it was a confounding influence in that, for at least some users, the experience probably did not approach a level of engagement with the scenarios and tasks that could be legitimately described as PBL. The data collected in this study did not permit analysis of the impact of differential patterns of use on SE. Thus it is possible that the observed increase in SE for the experimental group might result from interaction with the resources, independent of engagement with the PBL tasks.

6.4 Recommendations for further development & research

The present study has confirmed the possibility of creating interactive multimedia using problem-based learning as the design framework and has found evidence of the effectiveness of the materials for enhancing preservice teachers' self-efficacy for teaching with computers. In so doing, it has highlighted possibilities for further development of IMM-PBL materials and related research into their effectiveness.

6.4.1 Development

All four scenarios in the IMM-PBL materials dealt with the use of ICTs in primary school classrooms. Although most participants in the evaluation were preparing to be primary school teachers, there were some in early childhood and secondary programs who expressed a desire to work with scenarios more directly related to their areas of interest. Additional scenarios with a focus on early childhood and secondary teaching could be developed. It would also be possible to create scenarios with a focus on issues other than the integration of information technology. The four existing scenarios have some common features that might form the basis of a template around which scenarios with different content emphases could be built.

Participants in the evaluation experienced some frustration because the laboratory configuration did not retain cookie data between sessions. This prevented users from easily resuming where they had left off in a previous session. Even if the cookie were retained in the laboratory and stored on a server, so that it would be available to the same user from any computer in the laboratory system, it would not provide portability of data for users who wished to work with the materials away from the laboratory. One possible solution would be to place the IMM-PBL materials on a web server and develop a server-side mechanism to store user data. A hybrid arrangement would permit storage of web pages and user data on a server and retain the CD-ROM for large files such as video that would present problems for transmission across the Internet. Such a system would offer advantages for periodic updating of some components but would require constant access to the web server for user tracking. This might not be practical or convenient for some locations. An alternative would be to use a system similar to some games in which, when the user exits, a code is provided to allow activity to be resumed at the same point in the materials. Further investigation and trials might result in one of these approaches or an alternative that would enable users to access the materials in different locations and preserve the flow through the materials.

Some of the PBL practitioners and beta evaluators commented on the lack of mechanisms, or even explicit encouragement, for users to work collaboratively. A future version of the IMM-PBL materials might include mechanisms to facilitate interaction among users. The use of computer mediated communication might enable users separated by distance or time to contribute to collaborative problem solving processes. Another possibility would be the introduction of a mechanism that would permit users to contribute their solutions or responses to a collection housed on a web server. Such a mechanism would add to the diversity of points of view available to other users and offer the possibility of forms of feedback other than simple comparison with the solutions of others.

One participant in the evaluation expressed a desire for access to sample responses before constructing a personal response. In a PBL context, this presents a difficulty since it would amount to providing one or more alternative solutions before users engaged with the problem. Nevertheless, the desire of users to view a "model" performance before attempting their own is understandable. A compromise position might provide models that illustrate appropriate forms of response using content unrelated to the specific problem.

Other users suggested addition of a table of contents or index that would support access to resources other than through the scenarios. It would be relatively simple to create such a mechanism. Although it was considered in the design of the materials, it was rejected because it might discourage engagement with the scenarios. Many of the resources are available from the desktop through the laptop computer or folder mechanisms and some participants in the evaluation appeared to focus on exploring them, suggesting that the earlier concern about the potential for distraction was well founded. A context in which users were held accountable for working through the scenarios might provide the necessary motivation to engage with the scenarios even if an index of resources were available. Alternatively, it might be feasible to include a table of contents or index but restrict its availability depending upon the context in which the materials were being used. Such a system would certainly offer advantages for use in demonstrations or if the resources were required for presentation in the course of teaching.

6.4.2 Research

As noted above, the conditions that applied in the evaluation left room for doubt about whether the PBL scenarios increased the effect of the materials beyond what might be have been possible using the resources included in the materials without the problem-based context. This question invites further investigation, which might be undertaken in one of at least two ways.

One approach to investigating any additional effect resulting from the incorporation of PBL over and above the resources would be to compare the effects on users who approach the materials in different ways. This might be accomplished by allowing users to interact as they preferred and comparing the effects achieved for different patterns of interaction as determined by observation or other means. Alternatively, two or more classes might be structured so as to encourage different methods of use.

A different approach might be to construct slight variations of the materials. One version might enable access to the resources without the PBL scenarios. Another might restrict access to resources without engaging in the PBL scenarios. Again the effects of different conditions might be compared.

More detailed studies of user interaction with the materials might yield additional understanding about how users approach the materials and what use is made of various features of the IMM-PBL materials. Such studies might be undertaken by recording users' interactions using video or "dribble file" techniques to maintain a detailed record of a user's progress through the materials. Insights gained from such studies could assist in the development of more effective materials.

A fundamental assumption of this study has been that pre-service teachers' self-efficacy for teaching with computers is a variable of interest because it points towards subsequent use of computers in their classrooms. Self-efficacy theory suggests that this should be the case and there is evidence that teachers' beliefs in their capacity to use computers do affect their decisions to use them. However, there is no direct evidence that pre-service teachers' self-efficacy for computer use as measured in this study is a valid predictor of future use of computers in teaching. Studies of the relationship between self-efficacy and computer use by teachers in the field and studies of pre-service teachers' use of computers after graduation could shed additional light on the validity of self-efficacy as a criterion variable for studies such as this one.

If self-efficacy for teaching with computers is a valid predictor of future computer use in teaching, then there would be value in having a clearer understanding of the factors which influence the development of that self-efficacy. Further studies of the relationship to self-efficacy for teaching with computers of variables such as self-efficacy for computer technologies, Innovativeness and others could lead to a better understanding of how to enhance the self-efficacy of pre-service and beginning teachers.

Finally, if IMM-PBL as developed in this study is able to effect an increase in knowledge and self-efficacy for teaching with computers, then IMM-PBL with a focus on other aspects of teaching may be able to enhance the capacities of pre-service teachers for other aspects of their professional role. It is unlikely that simulated experiences of the type provided by IMM-PBL could ever provide a complete substitute for practical experience in teacher education but they may provide valuable preliminary and supplementary experiences. Certainly there are potential benefits in the self-instructional nature of IMM-PBL and its related capacity to support PBL experiences for learners who may be isolated by space or time from conventional PBL offerings. At a time when there is increasing demand for lifelong professional learning opportunities to be offered in flexible modes this may be a significant advantage of IMM-PBL.

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Appendix A – PBL validation

Integrating Information Technology into Teaching Multimedia Materials
Implementation of Problem-Based Learning Principles

The *Integrating IT into Teaching* materials represent an attempt to design multimedia incorporating the principles of problem-based learning (PBL) as a framework for the instructional design. This questionnaire seeks to obtain expert opinion about the extent to which specific characteristics of PBL have been successfully incorporated in the design. The nine items are based upon principles identified in the following sources:

Bridges, E. M. (1992). *Problem based learning for administrators*. Eugene: ERIC Clearinghouse on Educational Management.

Charlin, B., Mann, K., & Hansen, P. (1998). The many faces of problem-based learning: A framework for understanding and comparison. *Medical Teacher, 20* (4), 323-330.

Reviewer details

Please complete the following details which will assist in interpreting your comments.

Name: ________________________________ E-mail address: ___________________________________

Experience of PBL: ____

For each item use the five point scale (1 = strongly disagree to 5 = strongly agree) to rate the degree to which you agree that the materials incorporate the relevant principle. The space for comments may be used to amplify your opinion.

1 The materials present a problem as the starting point for learning.

Rating (1 = strongly disagree to 5 = strongly agree - Mark one): 1 2 3 4 5 NA

Comments: ____

____

____

2 The problems presented in the materials are relevant to the future professional lives of teachers and provide a meaningful context for learning about teaching.

Rating (1 = strongly disagree to 5 = strongly agree - Mark one): 1 2 3 4 5 NA

Comments: ____

____

____

3 Materials of this type could be used in a sustained educational approach and not simply as an atypical insertion in an otherwise conventional educational experience.

Rating (1 = strongly disagree to 5 = strongly agree - Mark one): 1 2 3 4 5 NA

Comments: ____

____

____

4 The materials are consistent with an approach in which learners assume significant responsibility for their own learning.

Rating (1 = strongly disagree to 5 = strongly agree - Mark one): 1 2 3 4 5 NA

Comments: ____

____

____

5 The materials would encourage learners to become active processors of information.

Rating (1 = strongly disagree to 5 = strongly agree - Mark one): 1 2 3 4 5 NA

Comments: ____

____

____

6 The materials would provide opportunities for learners to activate prior relevant knowledge.

Rating (1 = strongly disagree to 5 = strongly agree - Mark one): 1 2 3 4 5 NA

Comments: ____

____

____

7 The materials would provide opportunities for learners to elaborate and organise their knowledge.

Rating (1 = strongly disagree to 5 = strongly agree - Mark one): 1 2 3 4 5 NA

Comments: ____

____

____

8 The materials are consistent with an approach in which knowledge is organised around problems rather than disciplines.

Rating (1 = strongly disagree to 5 = strongly agree - Mark one): 1 2 3 4 5 NA

Comments: ____

____

____

9 The materials are consistent with the experience of learning in small groups rather than through lectures.

Rating (1 = strongly disagree to 5 = strongly agree - Mark one): 1 2 3 4 5 NA

Comments: ____

____

____

Appendix B – Prototype trial pre-test questionnaire

INTEGRATING TECHNOLOGY INTO TEACHING QUESTIONNAIRE

Data collected in this questionnaire is for research purposes only. Strict confidentiality will be maintained for individual responses. Your student number (or name) will be used only to allow comparison with your results on a subsequent questionnaire. Please answer all questions by completing the gaps or ticking boxes as appropriate.

Student Number: ____________________ OR Name: ______________________

Sex: ❑ Male ❑ Female	Age: ______
Tick the box corresponding to the number of hours you spend working with a computer in a typical week. ❑ less than 1 ❑ 1 - 5 ❑ 6 - 10 ❑ more than 10	

The statements below concern how you might feel about computers. For each statement, indicate the strength of your agreement or disagreement by a tick in the appropriate box. There are no right or wrong answers. Your initial response is probably the most accurate reflection of your thinking so move quickly from each statement to the next.

1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree	Strongly Disagree 1	2	3	Strongly Agree 4
1. Anything that computer technologies can be used for, I can do just as well some other way.	❑	❑	❑	❑
2. Computer technologies are confusing to me.	❑	❑	❑	❑
3. Computer technologies can be used to assist me in organising my work.	❑	❑	❑	❑
4. I am anxious about computers because I don't know what to do if something goes wrong.	❑	❑	❑	❑
5. I am confident about my ability to do well in a course that requires me to use computer technologies.	❑	❑	❑	❑
6. I am not the type to do well with computer technologies.	❑	❑	❑	❑
7. I could use computer technologies to access many types of information for my work.	❑	❑	❑	❑
8. I do not feel threatened by the impact of computer technologies.	❑	❑	❑	❑
9. I do not think that computer technologies will be useful to me in my profession.	❑	❑	❑	❑
10. I don't have any use for computer technologies on a day-to-day basis.	❑	❑	❑	❑
11. I don't see how I can use computer technologies to learn new skills.	❑	❑	❑	❑
12. I feel at ease learning about computer technologies.	❑	❑	❑	❑
13. I feel comfortable about my ability to work with computer technologies.	❑	❑	❑	❑
14. If I can use word-processing software, I will be more productive.	❑	❑	❑	❑
15. Knowing how to use computer technologies will not be helpful in my future work.	❑	❑	❑	❑
16. The thought of using computer technologies frightens me.	❑	❑	❑	❑
17. Using computer technologies in my job will only mean more work for me.	❑	❑	❑	❑
18. Using computer technologies to communicate with others over a network can help me to be more effective in my job.	❑	❑	❑	❑
19. With the use of computer technologies, I can create materials to enhance my performance on the job.	❑	❑	❑	❑

Please continue on the next page

The next set of statements concerns how you might feel about various aspects of working with computers. For each statement, indicate the strength of your agreement or disagreement by a tick in the appropriate box.

1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree	Strongly Disagree 1	2	3	Strongly Agree 4
20. I feel confident accessing previous files with a word processing program.	❑	❑	❑	❑
21. I feel confident conducting a search for Internet resources.	❑	❑	❑	❑
22. I feel confident copying an individual file.	❑	❑	❑	❑
23. I feel confident decoding a file which has been downloaded from the Internet.	❑	❑	❑	❑
24. I feel confident deleting messages received on e-mail.	❑	❑	❑	❑
25. I feel confident downloading a file from the Internet.	❑	❑	❑	❑
26. I feel confident editing previous spreadsheet files.	❑	❑	❑	❑
27. I feel confident entering appropriate formulas for calculation in a spreadsheet.	❑	❑	❑	❑
28. I feel confident entering data in a spreadsheet.	❑	❑	❑	❑
29. I feel confident entering records in a database.	❑	❑	❑	❑
30. I feel confident finding a file that I need.	❑	❑	❑	❑
31. I feel confident formatting data fields in a database.	❑	❑	❑	❑
32. I feel confident formatting text (e.g., bold, underlining) while word processing.	❑	❑	❑	❑
33. I feel confident formatting the columns and rows in a spreadsheet.	❑	❑	❑	❑
34. I feel confident forwarding messages received on e-mail.	❑	❑	❑	❑
35. I feel confident getting into a database on compact disc and starting a literature search.	❑	❑	❑	❑
36. I feel confident getting rid of files when they are no longer needed.	❑	❑	❑	❑
37. I feel confident getting software up and running.	❑	❑	❑	❑
38. I feel confident handling a floppy disk correctly.	❑	❑	❑	❑
39. I feel confident installing a new program.	❑	❑	❑	❑
40. I feel confident logging on to e-mail.	❑	❑	❑	❑
41. I feel confident logging off from e-mail.	❑	❑	❑	❑
42. I feel confident making a printed copy of a web page.	❑	❑	❑	❑
43. I feel confident making corrections while word processing.	❑	❑	❑	❑
44. I feel confident moving blocks of text while word processing.	❑	❑	❑	❑
45. I feel confident naming data fields in a database.	❑	❑	❑	❑
46. I feel confident naming the columns and rows in a spreadsheet.	❑	❑	❑	❑
47. I feel confident organising and managing files.	❑	❑	❑	❑
48. I feel confident printing out files I've written while word processing.	❑	❑	❑	❑
49. I feel confident printing out records in a database.	❑	❑	❑	❑
50. I feel confident printing out the spreadsheet.	❑	❑	❑	❑
51. I feel confident reading messages on e-mail.	❑	❑	❑	❑
52. I feel confident recording an Internet site so that I can find it again.	❑	❑	❑	❑
53. I feel confident renaming a word-processing file to make a back-up copy.	❑	❑	❑	❑
54. I feel confident responding to messages on e-mail.	❑	❑	❑	❑
55. I feel confident responding privately to messages sent to more than one person on e-mail.	❑	❑	❑	❑
56. I feel confident saving a spreadsheet file.	❑	❑	❑	❑
57. I feel confident saving database files.	❑	❑	❑	❑
58. I feel confident saving documents I've written with a word-processing program.	❑	❑	❑	❑
59. I feel confident searching records in a database with specific terms.	❑	❑	❑	❑
60. I feel confident selecting search terms for a database literature search.	❑	❑	❑	❑
61. I feel confident selecting the right database on compact disc for a specific topic.	❑	❑	❑	❑
62. I feel confident sending mail messages on e-mail.	❑	❑	❑	❑
63. I feel confident sending the same mail message to more than one person on e-mail.	❑	❑	❑	❑
64. I feel confident sorting records in a database.	❑	❑	❑	❑
65. I feel confident using a browser to view sites on the Internet.	❑	❑	❑	❑
66. I feel confident using a database on compact disc, such as ERIC, AEI, GPO, SSO, etc.	❑	❑	❑	❑
67. I feel confident using a printed address to locate an Internet site.	❑	❑	❑	❑
68. I feel confident using a word-processing program to write a letter or a report.	❑	❑	❑	❑
69. I feel confident using descriptors from a database literature search to obtain new search terms.	❑	❑	❑	❑
70. I feel confident using the print function in a database search on compact disc.	❑	❑	❑	❑
71. I feel confident using the searching feature in a word processing program.	❑	❑	❑	❑
72. I feel confident using the spell checker while word processing.	❑	❑	❑	❑

Please continue on the next page

The next set of statements concerns how you might feel about various aspects of classroom teaching. For each statement, indicate the strength of your agreement or disagreement by a tick in the appropriate box.

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree	Strongly Disagree 1	2	3	4	Strongly Agree 5
73. Too much pupil time is spent on guidance and activities and too little on academic preparation.	❑	❑	❑	❑	❑
74. Being friendly with pupils often leads them to become too familiar.	❑	❑	❑	❑	❑
75. It is more important for pupils to learn to obey rules than that they make their own decisions.	❑	❑	❑	❑	❑
76. Student governments are a good “safety valve” but should not have much influence on school policy.	❑	❑	❑	❑	❑
77. Pupils can be trusted to work together without supervision.	❑	❑	❑	❑	❑
78. If a pupil uses obscene or profane language in school, it must be considered a moral offence.	❑	❑	❑	❑	❑
79. A few pupils are just young hoodlums and should be treated accordingly.	❑	❑	❑	❑	❑
80. It is often necessary to remind pupils that their status in schools differs from that of teachers.	❑	❑	❑	❑	❑
81. Pupils cannot perceive the difference between democracy and anarchy in the classroom.	❑	❑	❑	❑	❑
82. Pupils often misbehave in order to make the teacher look bad.	❑	❑	❑	❑	❑
83. When a student shows improvement in using the computer, it is often because the teacher exerted a little extra effort.	❑	❑	❑	❑	❑
84. When students’ attitude toward using computers improves, it is often due to their teacher having used the classroom computer in more effective ways.	❑	❑	❑	❑	❑
85. If students are unable to use the computer, it is most likely due to their teachers’ ineffective modelling.	❑	❑	❑	❑	❑
86. The inadequacy of a student’s computer background can be overcome by good teaching.	❑	❑	❑	❑	❑
87. The teacher is generally responsible for students’ competence in computer usage.	❑	❑	❑	❑	❑
88. Students’ computer ability is directly related to their teacher’s effectiveness in classroom computer use.	❑	❑	❑	❑	❑
89. If parents comment that their child is showing more interest in computers, it is probably due to the performance of the child’s teacher.	❑	❑	❑	❑	❑
90. I am continually finding better ways to use the computer in my classroom.	❑	❑	❑	❑	❑
91. Even when I try very hard, I do not use the computer as well as I do other instructional resources.	❑	❑	❑	❑	❑
92. I know the steps necessary to use the computer in an instructional setting.	❑	❑	❑	❑	❑
93. I am not very effective in monitoring students’ computer use in my classroom.	❑	❑	❑	❑	❑
94. I generally employ the computer in my classroom effectively.	❑	❑	❑	❑	❑
95. I understand computer capabilities well enough to be effective using them in my classroom.	❑	❑	❑	❑	❑
96. I find it difficult to explain to students how to use the computer.	❑	❑	❑	❑	❑
97. I am typically able to answer students’ questions which relate to the computer.	❑	❑	❑	❑	❑
98. I wonder if I have the necessary skills to use the computer for instruction.	❑	❑	❑	❑	❑
99. Given a choice, I would not invite the principal to evaluate my computer-based instruction.	❑	❑	❑	❑	❑
100. When students have difficulty with the computer, I am usually at a loss as to how to help them.	❑	❑	❑	❑	❑
101. When using the computer, I usually welcome student questions.	❑	❑	❑	❑	❑
102. I do not know what to do to turn students on to computers.	❑	❑	❑	❑	❑
103. Whenever I can, I avoid using computers in my classroom.	❑	❑	❑	❑	❑

Please continue on the next page

The next set of statements concerns how you might feel about teaching. For each statement, indicate the strength of your agreement or disagreement by a tick in the appropriate box. There are no right or wrong answers.

1 = Strongly Disagree, 6 = Strongly Agree	Strongly Disagree 1	2	3	4	5	Strongly Agree 6
104. When a student does better than usually, many times it is because the teacher exerts a little extra effort.	❑	❑	❑	❑	❑	❑
105. The hours in my class have little influence on students compared to the influence of their home environment.	❑	❑	❑	❑	❑	❑
106. The amount a student can learn is primarily related to family background.	❑	❑	❑	❑	❑	❑
107. If students aren't disciplined at home, they aren't likely to accept any discipline.	❑	❑	❑	❑	❑	❑
108. I have not been trained to deal with many of the learning problems my students have.	❑	❑	❑	❑	❑	❑
109. When a student is having difficulty with an assignment, I often have trouble adjusting it to his/her level.	❑	❑	❑	❑	❑	❑
110. When a student gets a better grade than he/she usually gets, it is usually because I found better ways of teaching that student.	❑	❑	❑	❑	❑	❑
111. When I really try, I can get through to most difficult students.	❑	❑	❑	❑	❑	❑
112. I am very limited in what I can achieve because a student's home environment is a large influence on his/her achievement.	❑	❑	❑	❑	❑	❑
113. Teachers are not a very powerful influence on student achievement when all factors are considered.	❑	❑	❑	❑	❑	❑
114. When the grades of students improve, it is usually because their teachers found more effective teaching approaches.	❑	❑	❑	❑	❑	❑
115. If a student masters a new concept quickly, this might be because the teacher knew the necessary steps in teaching that concept.	❑	❑	❑	❑	❑	❑
116. If parents would do more for their children, teachers could do more.	❑	❑	❑	❑	❑	❑
117. If a student did not remember information I gave in a previous lesson, I would know how to increase his/her retention in the next lesson.	❑	❑	❑	❑	❑	❑
118. The influence of a student's home experiences can be overcome by good teaching.	❑	❑	❑	❑	❑	❑
119. If a student in my class becomes disruptive and noisy, I feel assured that I know some techniques to redirect him/her quickly.	❑	❑	❑	❑	❑	❑
120. Even a teacher with good teaching abilities may not reach many students.	❑	❑	❑	❑	❑	❑
121. If a student couldn't do a class assignment, most teachers would be able to accurately assess whether the assignment was at the correct level of difficulty.	❑	❑	❑	❑	❑	❑
122. If I really try hard, I can get through to even the most difficult or unmotivated students.	❑	❑	❑	❑	❑	❑
123. When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance depends upon his/her home environment.	❑	❑	❑	❑	❑	❑
124. My teacher training program and/or experience did not give me the necessary skills to be an effective teacher.	❑	❑	❑	❑	❑	❑

The next set of statements concerns how you might feel about change. For each statement, indicate the strength of your agreement or disagreement by a tick in the appropriate box. There are no right or wrong answers.

1 = Strongly Disagree, 2 = Disagree, 3 = Moderately Disagree, 4 = Undecided, 5 = Moderately Agree, 6 = Agree, 7 = Strongly Agree	Strongly Disagree 1	2	3	4	5	6	Strongly Agree 7
125. I am generally cautious about accepting new ideas.	❑	❑	❑	❑	❑	❑	❑
126. I rarely trust new ideas until I can see whether the vast majority of people around me accept them.	❑	❑	❑	❑	❑	❑	❑
127. I am aware that I am usually one of the last people in my group to accept something new.	❑	❑	❑	❑	❑	❑	❑
128. I am reluctant about adopting new ways of doing things until I see them working for people around me.	❑	❑	❑	❑	❑	❑	❑
129. I find it stimulating to be original in my thinking and behaviour.	❑	❑	❑	❑	❑	❑	❑
130. I tend to feel that the old way of living and doing things is the best way.	❑	❑	❑	❑	❑	❑	❑
131. I am challenged by ambiguities and unsolved problems.	❑	❑	❑	❑	❑	❑	❑
132. I must see other people using new innovations before I will consider them.	❑	❑	❑	❑	❑	❑	❑
133. I am challenged by unanswered questions.	❑	❑	❑	❑	❑	❑	❑
134. I often find myself sceptical of new ideas.	❑	❑	❑	❑	❑	❑	❑

Thank you for completing this questionnaire

Appendix C – Prototype evaluation questionnaire

Integrating Technology in Teaching
Prototype Evaluation

Integrating Technology in Teaching is a USQ Faculty of Education multimedia project which is supported by the National Priority Reserve Fund. When it is completed, the package will be distributed on CD-ROM and will include several problem-based learning experiences with a focus on the integration of information and communications technologies in primary school classrooms.

As part of the design and development process a prototype comprising one problem sequence is being trialed with a group of final year students. The evaluation data obtained from this trial will be used to improve the final product.

Please respond to the following items with respect to the Integrating Technology in Teaching multimedia package with which you have worked.

For each statement in this set circle, the code which best reflects your level of agreement with the statement.
SD = Strongly Disagree D = Disagree N = Neutral A = Agree SA = Strongly Agree

1.	I was enthusiastic about using the multimedia package as a part of my study	SD	D	N	A	SA
2.	The problem presented in this multimedia package was **NOT** closely related to the everyday experience of teaching	SD	D	N	A	SA
3.	The problem presented in this multimedia package was relevant to my future work as a teacher	SD	D	N	A	SA
4.	Using this multimedia package did **NOT** help to increase my confidence for making professional decisions	SD	D	N	A	SA
5.	Using this multimedia package helped to improve my knowledge of classroom management	SD	D	N	A	SA
6.	Working with this multimedia package did **NOT** help me to prepare better for using technology in my classroom	SD	D	N	A	SA
7.	Using this multimedia package helped to improve my understanding of integrating technology into teaching	SD	D	N	A	SA
8.	Using this multimedia package increased my confidence for dealing with related issues in my own classroom	SD	D	N	A	SA
9.	In my opinion this type of multimedia package is a very effective learning tool	SD	D	N	A	SA
10.	The quality of the sound on this multimedia package is very good	SD	D	N	A	SA
11.	The visual quality of the video presented on this multimedia package is very good	SD	D	N	A	SA
12.	The operating instructions included on the multimedia package were sufficient to allow me to use it effectively	SD	D	N	A	SA
13.	The textual materials on the multimedia package were of high quality	SD	D	N	A	SA
14.	There was **NOT** adequate feedback for the tasks on the multimedia package	SD	D	N	A	SA
15.	The problem on the multimedia package progressed in a logical fashion	SD	D	N	A	SA
16.	Navigation through the multimedia package was **NOT** difficult	SD	D	N	A	SA
17.	Sufficient time was allowed to work through the tasks	SD	D	N	A	SA
18.	The resources on the multimedia package were difficult to access	SD	D	N	A	SA

19. Colours used in the multimedia package interface were suitable SD D N A SA
20. There were **NO** difficulties in operating the software SD D N A SA

For each of the following elements circle the number from 1 (Much less) to 5 (Much more) which best represents how you think a change in the amount of that element would improve the overall package. For instance, if you believe that more video segments would improve the overall value of the package then you would circle 4 or 5 on the line beginning with 23.

	Much Less				Much More
21. Text resources	1	2	3	4	5
22. Audio (without video)	1	2	3	4	5
23. Video	1	2	3	4	5
24. Photographs	1	2	3	4	5
25. Drawings	1	2	3	4	5
26. Theoretical background	1	2	3	4	5
27. Sample solutions	1	2	3	4	5

28. What were your first impressions of the multimedia package materials?

....

....

....

29. What are the weakest points or parts of the software? Please explain.

....

....

....

30. Which was your favourite part or section of the software? Please explain.

....

....

....

31. How might the multimedia package be improved?

....

....

....

32. What do you think was the greatest benefit to you from using the multimedia package?

....

....

....

33. What, if any, benefit to your professional development do you believe you gain through working with materials like this multimedia package?

....

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....

34. What specific aspects of teaching with technology did you learn about by working with this multimedia package?

....

....

....

35. Do you think that other teachers would gain insights into teaching with technology by using this multimedia package?

....

....

....

36. Mark with a ✔ in the space beside each of the following aspects of teaching and planning for which you were able to gain some insight during your use of the multimedia package.

[_] teachers' self organisation
[_] classroom management
[_] travel patterns
[_] use of other personnel
[_] teachers' knowledge of technology
[_] sequencing of activities
[_] integrating content
[_] dealing with diverse groups of children
[_] assessing student work
[_] physical layout of a classroom
[_] room arrangements
[_] arrangements of desks
[_] teaching strategies
[_] selection of appropriate strategies
[_] teaching skills
[_] managing small groups
[_] checking for understanding

37. Please add any other comments you may have about the materials you have worked with.

....

....

....

Thank you for your assistance in the evaluation of the multimedia package.

Appendix D – Beta evaluation questionnaire

Integrating Technology into Teaching
A Problem-based Learning Approach

Trial Version Evaluation

The *Integrating Technology into Teaching* package is designed primarily for use by pre-service teachers although it might also be of interest and benefit for professional development of teachers.

The materials have been developed as web pages and are viewed using a standard web browser with plugins for QuickTime, ShockWave and PDF. They are presented on CD-ROM to facilitate inclusion of a quantity of digitised video.

This evaluation process is intended to identify problems and/or deficiencies that should be addressed prior to release of the final version of the software. Three sets of issues are considered:
1. Interface design (characteristics of the software such as ease of use and navigability)
2. Educational design (arrangement of the content and activities to support an effective learning experience)
3. Content (relevance and realism of the content in relation to the work of teachers)

The panel of reviewers will include members with expertise in each of the three areas but individual members will not necessarily have expertise in all three areas. Reviewers may prefer not to respond in those areas where they do not feel able to contribute.

Please inspect the materials using the statements listed on the following pages as guides. Record a rating (1 = poor to 5 = excellent) for each statement and add any relevant comments in the space provided.

Remember that the intention of this evaluation is to identify problems so that they can be addressed in then final version of the software. It will assist greatly if you can accurately describe any problem including where in the materials it occurred and what you observed immediately before and after encountering the problem. Suggestions for solutions to the problem or improvements are welcome.

Begin by reading through this questionnaire before working with the software.

As you work through the software you should try to inspect as much as possible but, for this evaluation, it is not necessary for you to prepare a complete response to every task.

It will help if you make notes about any observations relevant to the evaluation as you work through the software and use those notes when completing the questionnaire.

Reviewer details

Please complete the following details which will assist us to interpret your comments and to contact you if additional information is required to help us rectify a problem you have identified.

Name: ______________________________ E-mail address: ___________________________________

Telephone: ___________________________ Facsimile: ______________________________________

Qualifications and experience

Software design & development: ____

Instructional design: ____

Teaching: ____

How would you describe your general level of computer skills? ____

Review System Characteristics

Please provide some details about the computer system you are using for the review:

Operating System:	[__]	Windows	version: __________
	[__]	Macintosh	version: __________

Hardware:	Processor (Pentium II, G3, etc)	__________
	System speed (in MHz)	__________
	Installed RAM (in Mb)	__________
	Screen size (640 x 480, 800 x 600, etc)	__________

Browser:	[__]	Microsoft Internet Explorer	version: __________
	[__]	Netscape Navigator/Communicator	version: __________

Other details you consider relevant:

Interface design

The statements below reflect some widely accepted principles of interface design. Using them as a guide, inspect the user interface with particular attention to problems and deficiencies that should be rectified in a release version of the software. For each principle use the five point scale (1 = poor to 5 = excellent) to rate the degree to which you think this software applies the principle. Use the comment space to identify specific issues that should be addressed before release of the software. If the space is insufficient feel free to attach additional pages.

Ensures visibility of system status: The software keeps the user informed about what is going on through appropriate and timely feedback.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Maximises match between the system and the real world: The software speaks the users' language rather than jargon. Information appears in a natural and logical order.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Maximises user control and freedom: Users are able to exit locations and undo mistakes.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Maximises consistency and match with standards: Users do not have to wonder whether different words, situations or actions mean the same thing. Common platform standards are followed.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Prevents errors: The design provides guidance which reduces the risk of user errors.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Supports recognition rather than recall: Objects, actions and options are visible. The user does not have to rely on memory. Information is visible or easily accessed whenever appropriate.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Supports flexibility and efficiency of use: The software allows experienced users to use shortcuts and adjust settings to suit.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Uses aesthetic and minimalist design: The software provides an appealing overall design and does not display irrelevant or infrequently used information.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Helps users recognise, diagnose and recover from errors: Error messages are expressed in plain language, clearly indicate the problem and recommend a solution.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Provides help and documentation: The software provides appropriate online help and documentation which is easily accessed and related to the users' needs.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Educational design

The statements below reflect some principles of educational design in software. Using them as a guide, inspect the materials with particular attention to problems and deficiencies in educational design that should be rectified in a release version of the software. For each principle use the five point scale (1 = poor to 5 = excellent) to rate the degree to which you think this software applies the principle. Use the comment space to identify specific issues that should be addressed before release of the software. If the space is insufficient feel free to attach additional pages.

Clear goals and objectives: The software makes it clear to the learner what is to be accomplished and what will be gained from its use.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Context meaningful to domain and learner: The activities in the software are situated in practice and will interest and engage a learner.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Content clearly and multiply represented and multiply navigable: The message in the software is unambiguous. The software supports learner preferences for different access pathways. The learner is able to find relevant information while engaged in an activity.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Activities scaffolded: The software provides support for learner activities to allow working within existing competence while encountering meaningful chunks of knowledge.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Elicit learner understandings: The software requires learners to articulate their conceptual understandings as the basis for feedback.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

Formative evaluation: The software provides learners with constructive feedback on their endeavours.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

Performance should be 'criteria-referenced': The software will produce clear and measurable outcomes that would support competency-based evaluation.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

Support for transference and acquiring 'self-learning' skills: The software supports transference of skills beyond the learning environment and will facilitate the learner becoming able to self-improve.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

Support for collaborative learning: The software provides opportunities and support for learning through interaction with others through discussion or other collaborative activities.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

Relevance to Teacher Professional Development

The statements below relate to some aspects of the content and applicability of the materials in teacher development. Using them as a guide, inspect the materials paying particular attention to the relevance and potential effectiveness of the materials for teacher development in relation to integration of information and communications technologies. For each statement use the five point scale (1 = poor to 5 = excellent) to rate the degree to which you think this software applies the principle. Use the comment space to identify specific issues that should be addressed before release of the software. If the space is insufficient feel free to attach additional pages.

Establishment of context: The photographs, documents and other materials related to the simulated schools create a sense of immersion in a simulated reality.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Relevance to professional practice: The problem scenarios and included tasks are realistic and relevant to the professional practice of teachers.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Representation of professional responses to issues: The sample solutions represent a realistic range of teacher responses to the issues and challenge users to consider alternative approaches.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Relevance of reference materials: The reference materials included in the package are relevant to the problem scenarios and are at a level appropriate to the users.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Presentation of video resources: The video clips of teacher interviews and class activities are relevant and readily accessible to the user.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Assistance is supportive rather than prescriptive: The contextual help supports the user in locating relevant resources and dealing with the scenarios without restricting the scope of individual responses.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Materials are engaging: The presentation style and content of the software encourages a user to continue working through the scenarios.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Presentation of resources: The software presents useful resources for teacher professional development in an interesting and accessible manner.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Overall effectiveness of materials: The materials are likely to be effective in increasing teachers' confidence and capacity for integrating information technology into teaching and learning.

Rating (1 = poor to 5 = excellent - Mark one): 1 2 3 4 5 NA

Comments:____

____

____

Thank you for your assistance with this evaluation.

Appendix E – Multi-instrument questionnaire

INTEGRATING IT INTO TEACHING QUESTIONNAIRE 1

This questionnaire forms part of an investigation of ways to improve the preparation of teachers for teaching with computers. Data collected on the questionnaire will be used for research purposes only. They will form part of a PhD thesis and may be reported in conference and journal papers. Strict confidentiality will be maintained for individual responses. You are requested to identify yourself by student number and/or name to facilitate comparison of responses on this questionnaire with those to be collected later in the semester.

Peter Albion

Instructions

Most of the questions require you to indicate the strength of your agreement with a statement by ticking a box but some will require you to write a brief response. Please answer all questions by completing the gaps or ticking boxes as appropriate.

There are no right or wrong answers. Your initial response is probably the most accurate reflection of your thinking so move quickly from each statement to the next.

Student Number: ____________________ OR Name: ______________________

Sex: ❑ Male ❑ Female

Age: ❑ less than 21 ❑ 21 – 25 ❑ 26 – 30 ❑ more than 30

Mark the box corresponding to the course in which you are enrolled:

❑ SQ10 BEd (Early Childhood) ❑ SQ61 BEd (Primary)
❑ SQ54 BEd (Early Childhood) – Graduate Entry ❑ SQ53 BEd (Primary) – Graduate Entry
❑ Other (please specify) _________________________

Mark the boxes corresponding to any computer related subjects you studied at secondary school:

❑ Information Processing and Technology ❑ Practical Computer Methods
❑ Other (please specify) ___________________________

Mark the boxes corresponding to any computer related subjects you have studied at university:

❑ 66001 Introductory computing ❑ 75001 Introduction to computers
❑ 80173 Computing and design ❑ 80273 Learning through computer programming
❑ 80274 Hypermedia programming ❑ 80373 Instructional software design
❑ 80574 Computing in education ❑ 80575 Computer-based resources for education
❑ Other (please specify) _______________________________

Mark the box corresponding to the type of computer you have access to at your residence during semester:

❑ Windows ❑ Macintosh ❑ None ❑ Other (please specify) ____________________

Mark the box corresponding to the number of hours you spend working with a computer in a typical week of study:

❑ less than 1 ❑ 1 – 5 ❑ 6 – 10 ❑ more than 10

Please turn to the next page

The statements in this block concern how you might feel about computers. For each statement, indicate the strength of your agreement or disagreement by a tick in the appropriate box.

1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree	Strongly Disagree 1	2	3	Strongly Agree 4
1. I don't have any use for computer technologies on a day-to-day basis.	❑	❑	❑	❑
2. Using computer technologies to communicate with others over a network can help me to be more effective in my job.	❑	❑	❑	❑
3. I am confident about my ability to do well in a course that requires me to use computer technologies.	❑	❑	❑	❑
4. Using computer technologies in my job will only mean more work for me.	❑	❑	❑	❑
5. I do not think that computer technologies will be useful to me in my profession.	❑	❑	❑	❑
6. I feel at ease learning about computer technologies.	❑	❑	❑	❑
7. With the use of computer technologies, I can create materials to enhance my performance on the job.	❑	❑	❑	❑
8. I am not the type to do well with computer technologies.	❑	❑	❑	❑
9. If I can use word-processing software, I will be more productive.	❑	❑	❑	❑
10. Anything that computer technologies can be used for, I can do just as well some other way.	❑	❑	❑	❑
11. The thought of using computer technologies frightens me.	❑	❑	❑	❑
12. Computer technologies are confusing to me.	❑	❑	❑	❑
13. I could use computer technologies to access many types of information for my work.	❑	❑	❑	❑
14. I do not feel threatened by the impact of computer technologies.	❑	❑	❑	❑
15. I am anxious about computers because I don't know what to do if something goes wrong.	❑	❑	❑	❑
16. Computer technologies can be used to assist me in organising my work.	❑	❑	❑	❑
17. I don't see how I can use computer technologies to learn new skills.	❑	❑	❑	❑
18. I feel comfortable about my ability to work with computer technologies.	❑	❑	❑	❑
19. Knowing how to use computer technologies will not be helpful in my future work.	❑	❑	❑	❑

The statements in this block concern your level of confidence for performing certain tasks with a computer. For each statement, indicate the strength of your agreement or disagreement by a tick in the appropriate box.

1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree	Strongly Disagree 1	2	3	Strongly Agree 4
20. I feel confident using a word-processing program to write a letter or a report.	❑	❑	❑	❑
21. I feel confident accessing previous files with a word processing program.	❑	❑	❑	❑
22. I feel confident making corrections while word processing.	❑	❑	❑	❑
23. I feel confident formatting text (e.g., bold, underlining) while word processing.	❑	❑	❑	❑
24. I feel confident moving blocks of text while word processing.	❑	❑	❑	❑
25. I feel confident using the spell checker while word processing.	❑	❑	❑	❑
26. I feel confident using the searching feature in a word processing program.	❑	❑	❑	❑
27. I feel confident printing out files I've written while word processing.	❑	❑	❑	❑
28. I feel confident saving documents I've written with a word-processing program.	❑	❑	❑	❑
29. I feel confident renaming a word-processing file to make a back-up copy.	❑	❑	❑	❑
30. I feel confident logging on to e-mail.	❑	❑	❑	❑
31. I feel confident reading messages on e-mail.	❑	❑	❑	❑
32. I feel confident responding to mail messages on e-mail.	❑	❑	❑	❑
33. I feel confident deleting messages received on e-mail.	❑	❑	❑	❑
34. I feel confident sending mail messages on e-mail.	❑	❑	❑	❑
35. I feel confident sending the same mail message to more than one person on e-mail.	❑	❑	❑	❑
36. I feel confident responding privately to messages sent to more than one person on e-mail.	❑	❑	❑	❑
37. I feel confident forwarding messages received on e-mail.	❑	❑	❑	❑
38. I feel confident logging off from e-mail.	❑	❑	❑	❑
39. I feel confident formatting the columns and rows in a spreadsheet.	❑	❑	❑	❑
40. I feel confident naming the columns and rows in a spreadsheet.	❑	❑	❑	❑
41. I feel confident entering appropriate formulas for calculation in a spreadsheet.	❑	❑	❑	❑

Please turn to the next page

42. I feel confident entering data in a spreadsheet.	❑ ❑	❑ ❑
43. I feel confident editing previous spreadsheet files.	❑ ❑	❑ ❑
44. I feel confident printing out the spreadsheet.	❑ ❑	❑ ❑
45. I feel confident saving a spreadsheet file.	❑ ❑	❑ ❑
46. I feel confident formatting data fields in a database.	❑ ❑	❑ ❑
47. I feel confident naming data fields in a database.	❑ ❑	❑ ❑
48. I feel confident entering records in a database.	❑ ❑	❑ ❑
49. I feel confident searching records in a database with specific terms.	❑ ❑	❑ ❑
50. I feel confident sorting records in a database.	❑ ❑	❑ ❑
51. I feel confident printing out records in a database.	❑ ❑	❑ ❑
52. I feel confident saving database files.	❑ ❑	❑ ❑
53. I feel confident using a database on compact disc, such as ERIC, AEI, GPO, SSO, etc.	❑ ❑	❑ ❑
54. I feel confident selecting the right database on compact disc for a specific topic.	❑ ❑	❑ ❑
55. I feel confident selecting search terms for a database literature search.	❑ ❑	❑ ❑
56. I feel confident getting into a database on compact disc and starting a literature search.	❑ ❑	❑ ❑
57. I feel confident using descriptors from a database literature search to obtain new search terms.	❑ ❑	❑ ❑
58. I feel confident using the print function in a database search on compact disc.	❑ ❑	❑ ❑
59. I feel confident getting software up and running.	❑ ❑	❑ ❑
60. I feel confident handling a floppy disk correctly.	❑ ❑	❑ ❑
61. I feel confident finding a file that I need.	❑ ❑	❑ ❑
62. I feel confident installing a new program.	❑ ❑	❑ ❑
63. I feel confident copying an individual file.	❑ ❑	❑ ❑
64. I feel confident getting rid of files when they are no longer needed.	❑ ❑	❑ ❑
65. I feel confident organising and managing files.	❑ ❑	❑ ❑
66. I feel confident using a browser to view sites on the Internet.	❑ ❑	❑ ❑
67. I feel confident making a printed copy of a web page.	❑ ❑	❑ ❑
68. I feel confident recording an Internet site so that I can find it again.	❑ ❑	❑ ❑
69. I feel confident using a printed address to locate an Internet site.	❑ ❑	❑ ❑
70. I feel confident conducting a search for Internet resources.	❑ ❑	❑ ❑
71. I feel confident downloading a file from the Internet.	❑ ❑	❑ ❑
72. I feel confident decoding a file which has been downloaded from the Internet.	❑ ❑	❑ ❑

The next set of statements concerns how you might feel about various aspects of classroom management. For each statement, indicate the strength of your agreement or disagreement by a tick in the appropriate box.

1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree	Strongly Disagree	Strongly Agree
	1 2	3 4
73. Too much pupil time is spent on guidance and activities and too little on academic preparation.	❑ ❑	❑ ❑
74. Being friendly with pupils often leads them to become too familiar.	❑ ❑	❑ ❑
75. It is more important for pupils to learn to obey rules than that they make their own decisions.	❑ ❑	❑ ❑
76. Student governments are a good "safety valve" but should not have much influence on school policy.	❑ ❑	❑ ❑
77. Pupils can be trusted to work together without supervision.	❑ ❑	❑ ❑
78. If a pupil uses obscene or profane language in school, it must be considered a moral offence.	❑ ❑	❑ ❑
79. A few pupils are just young hoodlums and should be treated accordingly.	❑ ❑	❑ ❑
80. It is often necessary to remind pupils that their status in schools differs from that of teachers.	❑ ❑	❑ ❑
81. Pupils cannot perceive the difference between democracy and anarchy in the classroom.	❑ ❑	❑ ❑
82. Pupils often misbehave in order to make the teacher look bad.	❑ ❑	❑ ❑

Please turn to the next page

The next set of statements concerns how you might feel about the use of a computer in teaching. For each statement, indicate the strength of your agreement or disagreement by a tick in the appropriate box.

1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree	Strongly Disagree 1	2	3	Strongly Agree 4
83. When a student shows improvement in using the computer, it is often because the teacher exerted a little extra effort.	❑	❑	❑	❑
84. When students' attitude toward using computers improves, it is often due to their teacher having used the classroom computer in more effective ways.	❑	❑	❑	❑
85. If students are unable to use the computer, it is most likely due to their teachers' ineffective modelling.	❑	❑	❑	❑
86. The inadequacy of a student's computer background can be overcome by good teaching.	❑	❑	❑	❑
87. The teacher is generally responsible for students' competence in computer usage.	❑	❑	❑	❑
88. Students' computer ability is directly related to their teacher's effectiveness in classroom computer use.	❑	❑	❑	❑
89. If parents comment that their child is showing more interest in computers, it is probably due to the performance of the child's teacher.	❑	❑	❑	❑
90. I will continually find better ways to use the computer in my classroom.	❑	❑	❑	❑
91. Even if I try very hard, I will not use the computer as well as I do other instructional resources.	❑	❑	❑	❑
92. I know the steps necessary to use the computer in an instructional setting.	❑	❑	❑	❑
93. I will not be very effective in monitoring students' computer use in my classroom.	❑	❑	❑	❑
94. I will generally employ the computer in my classroom ineffectively.	❑	❑	❑	❑
95. I understand computer capabilities well enough to be effective using them in my classroom.	❑	❑	❑	❑
96. I will find it difficult to explain to students how to use the computer.	❑	❑	❑	❑
97. I will typically be able to answer students' questions which relate to the computer.	❑	❑	❑	❑
98. I question whether I have the necessary skills to use the computer for instruction.	❑	❑	❑	❑
99. Given a choice, I will not invite the principal to evaluate my computer-based instruction.	❑	❑	❑	❑
100. When students have difficulty with the computer, I will usually be at a loss as to how to help them.	❑	❑	❑	❑
101. When using the computer, I will usually welcome student questions.	❑	❑	❑	❑
102. I do not know what to do to turn students on to computers.	❑	❑	❑	❑
103. Whenever I can, I will avoid using computers in my classroom.	❑	❑	❑	❑

The next set of statements concerns how you might feel about change. For each statement, indicate the strength of your agreement or disagreement by a tick in the appropriate box. There are no right or wrong answers.

1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree	Strongly Disagree 1	2	3	Strongly Agree 4
104. I am generally cautious about accepting new ideas.	❑	❑	❑	❑
105. I rarely trust new ideas until I can see whether the vast majority of people around me accept them.	❑	❑	❑	❑
106. I am aware that I am usually one of the last people in my group to accept something new.	❑	❑	❑	❑
107. I am reluctant about adopting new ways of doing things until I see them working for people around me.	❑	❑	❑	❑
108. I find it stimulating to be original in my thinking and behaviour.	❑	❑	❑	❑
109. I tend to feel that the old way of living and doing things is the best way.	❑	❑	❑	❑
110. I am challenged by ambiguities and unsolved problems.	❑	❑	❑	❑
111. I must see other people using new innovations before I will consider them.	❑	❑	❑	❑
112. I am challenged by unanswered questions.	❑	❑	❑	❑
113. I often find myself sceptical of new ideas.	❑	❑	❑	❑

Please turn to the next page

The next set of statements concerns how you might feel about teaching. For each statement, indicate the strength of your agreement or disagreement by a tick in the appropriate box. There are no right or wrong answers.

1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree	Strongly Disagree 1	2	3	Strongly Agree 4
114. When a student does better than usually, many times it is because the teacher exerts a little extra effort.	❑	❑	❑	❑
115. The hours in my class have little influence on students compared to the influence of their home environment.	❑	❑	❑	❑
116. The amount a student can learn is primarily related to family background.	❑	❑	❑	❑
117. If students aren't disciplined at home, they aren't likely to accept any discipline.	❑	❑	❑	❑
118. I have not been trained to deal with many of the learning problems my students have.	❑	❑	❑	❑
119. When a student is having difficulty with an assignment, I often have trouble adjusting it to his/her level.	❑	❑	❑	❑
120. When a student gets a better grade than he/she usually gets, it is usually because I found better ways of teaching that student.	❑	❑	❑	❑
121. When I really try, I can get through to most difficult students.	❑	❑	❑	❑
122. I am very limited in what I can achieve because a student's home environment is a large influence on his/her achievement.	❑	❑	❑	❑
123. Teachers are not a very powerful influence on student achievement when all factors are considered.	❑	❑	❑	❑
124. When the grades of students improve, it is usually because their teachers found more effective teaching approaches.	❑	❑	❑	❑
125. If a student masters a new concept quickly, this might be because the teacher knew the necessary steps in teaching that concept.	❑	❑	❑	❑
126. If parents would do more for their children, teachers could do more.	❑	❑	❑	❑
127. If a student did not remember information I gave in a previous lesson, I would know how to increase his/her retention in the next lesson.	❑	❑	❑	❑
128. The influences of a student's home experiences can be overcome by good teaching.	❑	❑	❑	❑
129. If a student in my class becomes disruptive and noisy, I feel assured that I know some techniques to redirect him/her quickly.	❑	❑	❑	❑
130. Even a teacher with good teaching abilities may not reach many students.	❑	❑	❑	❑
131. If a student couldn't do a class assignment, most teachers would be able to accurately assess whether the assignment was at the correct level of difficulty.	❑	❑	❑	❑
132. If I really try hard, I can get through to even the most difficult or unmotivated students.	❑	❑	❑	❑
133. When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance depends upon his/her home environment.	❑	❑	❑	❑
134. My teacher training program and/or experience did not give me the necessary skills to be an effective teacher.	❑	❑	❑	❑

Please turn to the next page

The following questions relate to your personal opinions about some aspects of using computers in teaching. Please write your responses in the spaces provided. You may use point form if you prefer. There are no right or wrong answers.

135 What do you think would be the most important reason(s) for using computers in your future work as a teacher?

136 What do you think would be the best way(s) for you to continue to develop your knowledge and skills for teaching with computers during your teaching career?

137 What do you think would be the most important thing(s) to consider in your planning for teaching if you intended to use computers in your teaching?

138 What do you think would be the most significant effect(s) of using computers in your teaching?

139 What do you think would be the greatest challenge(s) you would face in using computers in your teaching?

140 What do you think would be the most important thing(s) to understand about the Internet if you were using it in your teaching?

This is the last page.
Thank you for your assistance with this questionnaire.

Appendix F – User evaluation questionnaire

Integrating Information Technology into Teaching Package Evaluation

Please respond to the following items with respect to the Integrating Information Technology into Teaching multimedia package with which you have worked in Unit 80955 – Information Technology for Teachers.

Student Number: ____________________ OR Name: ______________________

For each statement in this set circle, the code which best reflects your level of agreement with the statement.
SD = Strongly Disagree D = Disagree N = Neutral A = Agree SA = Strongly Agree

1.	I was enthusiastic about using the multimedia package as a part of my study	SD	D	N	A	SA
2.	The problems presented in this multimedia package were **NOT** closely related to the everyday experience of teaching	SD	D	N	A	SA
3.	The problems presented in this multimedia package were relevant to my future work as a teacher	SD	D	N	A	SA
4.	Using this multimedia package helped to increase my confidence for making professional decisions about teaching	SD	D	N	A	SA
5.	Using this multimedia package helped to improve my knowledge of classroom management	SD	D	N	A	SA
6.	Working with this multimedia package did **NOT** help me to prepare better for using technology in my classroom	SD	D	N	A	SA
7.	Using this multimedia package helped to improve my understanding of integrating technology into teaching	SD	D	N	A	SA
8.	Using this multimedia package increased my confidence for dealing with related issues in my own classroom	SD	D	N	A	SA
9.	In my opinion this type of multimedia package is a very effective learning tool	SD	D	N	A	SA
10.	The quality of the sound on this multimedia package is very good	SD	D	N	A	SA
11.	The visual quality of the video presented on this multimedia package is very good	SD	D	N	A	SA
12.	The operating instructions included with the multimedia package were sufficient to allow me to use it effectively	SD	D	N	A	SA
13.	The textual materials on the multimedia package were of high quality	SD	D	N	A	SA
14.	The multimedia package did **NOT** provide adequate feedback for the included tasks	SD	D	N	A	SA
15.	The problems on the multimedia package progressed in a logical fashion	SD	D	N	A	SA
16.	Navigation through the multimedia package was **NOT** difficult	SD	D	N	A	SA
17.	I was easily able to find sufficient time to work through the tasks	SD	D	N	A	SA
18.	The resources on the multimedia package were easy to access	SD	D	N	A	SA
19.	The visual design of the multimedia package was attractive and functional	SD	D	N	A	SA
20.	The multimedia package was easy to use	SD	D	N	A	SA

For each of the following elements circle the number from 1 (Much less) to 5 (Much more) which best represents how you think a change in the amount of that element would improve the overall package. For instance, if you believe that more video segments would improve the overall value of the package then you would circle 4 or 5 on the line beginning with 23.

	Much Less				Much More
21. Text resources	1	2	3	4	5
22. Audio (without video)	1	2	3	4	5
23. Video	1	2	3	4	5
24. Photographs	1	2	3	4	5
25. Drawings	1	2	3	4	5
26. Theoretical background	1	2	3	4	5
27. Sample solutions	1	2	3	4	5

28. What were your first impressions of the multimedia package materials?

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29. How would you describe the multimedia materials to a colleague who had not seen them?

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30. Which was your favourite part or section of the software? Please explain.

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31. What are the weakest points or parts of the software? Please explain.

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32. How might the multimedia package be improved?

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33. What do you think was the greatest benefit to you from using the multimedia package?

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34. What, if any, benefit to your professional development do you believe you gain through working with materials like this multimedia package?

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35. What specific aspects of teaching with technology did you learn about by working with this multimedia package?

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36. What insights into teaching with information technology do you think that other teachers might gain by using this multimedia package?

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37. Mark with a ✔ in the space beside each of the following aspects of teaching and planning for which you were able to gain some insight during your use of the multimedia package.

[_] teachers' self organisation

[_] classroom management

[_] travel patterns

[_] use of other personnel

[_] teachers' knowledge of technology

[_] sequencing of activities

[_] integrating content

[_] dealing with diverse groups of children

[_] assessing student work

[_] physical layout of a classroom

[_] room arrangements

[_] arrangements of desks

[_] teaching strategies

[_] selection of appropriate strategies

[_] teaching skills

[_] managing small groups

[_] checking for understanding

38. Please add any other comments you may have about the materials you have worked with.

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Thank you for your assistance in the evaluation of the multimedia package.

Appendix G – Participant journal

Integrating IT into Teaching – Student Journal

This journal will form part of a portfolio submission required for completion of Unit 80955. A sample of journal responses will also be used for research related to the effects of the *Integrating Information Technology into Teaching* multimedia CD-ROM. Data from the journal entries will be analysed for patterns in responses from individual students or groups of students. Strict confidentiality will be maintained for individual responses and any reports made in the form of a thesis or conference and journal papers will not include information which would permit identification of individual students.

Peter Albion

Instructions

Please complete a journal entry each time you work with the CD-ROM. It will assist if you indicate the time spent working with the materials in each session and identify the parts with which you worked. Please record your personal response to each of the questions in as much detail as you are able. If there is insufficient space you may use the back of this page or attach additional pages. There are no right or wrong responses.

Name: _____________________________ Date: ____________________

Time (in minutes) spent working with the CD-ROM in this session: ____________

What specific parts (resources, tasks, etc) of the CD-ROM materials did you work with in this session?

What did you do during this session? (Briefly describe what you did during the session)

What were the most important things you learned during this session?

What questions or issues that you identified as important to you emerged from this session?

What was your personal reaction to the activities you completed in this session?