DESIGNING MULTIMEDIA MATERIAL USING A PROBLEM-BASED LEARNING DESIGN

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ABSTRACT

Interactive Multimedia (IMM) and Problem-Based Learning (PBL) are two significant contributions to current developments in professional education. IMM offers the opportunity to present rich, multifaceted learning experiences that can be accessed by individual students who are separated by time or geography from more traditional learning opportunities. PBL offers instructional approaches that motivate students to engage with authentic problems of practice and to develop the attitudes and skills required for lifelong independent learning. PBL has not been widely reported as an instructional design for IMM, almost certainly due to the emphasis on group interaction as a component of typical PBL implementations and the individualised nature of IMM. This paper discusses some issues underlying application of the principles of PBL to the development of IMM materials and describes how they have been resolved in the case of an IMM-PBL project for teacher education.

KEY WORDS

Problem based learning, interactive, multimedia, instructional design

1. INTRODUCTION

The concept of ‘flexible delivery’ as promoted within higher education is elusive. On the one hand it has been suggested that, in theory at least, it will enable the university to give people “what they want, where they want it, when they want it” (Swannell, 1997). On the other hand, in practice ‘flexible delivery’ sometimes appears to be code for a process of transferring print materials to CD-ROM or the World Wide Web with the intent of shifting costs of printing to the users.

Information and communications technologies typically associated with ‘flexible delivery’ do offer opportunities to make worthwhile changes to the manner in which educational materials are delivered. Information presented using computer systems can offer active links to additional content contained in the distribution package or available elsewhere and it can include interactive components such as simulations. Electronic mail and other computer-based communications technologies make it possible for interactions among teachers and students to be conducted over distances and with a measure of speed and convenience far beyond that possible with the postal service or even the telephone.

Clearly these technologies have the potential to make certain types of educational experiences more accessible and they go some way towards increasing flexibility in respect of where and when educational experience is available. It is not so clear that they offer users 'what they want' or, perhaps more importantly, 'what they need' to achieve particular educational goals.

When new technologies are introduced into education, whether for 'flexible delivery' or for other reasons, attention is naturally drawn to changes in the instructional media because these are usually clearly visible to both teacher and learner. As a consequence of these visible changes it is tempting to assume that any observed changes in outcomes are caused by the changes in media.

However, Clark (1994) has argued that changes in learning outcomes are not influenced at all by media and that when the evidence appears to point to such effects it is as a result of a confounding of media and method. In his view decisions about media should aim to achieve delivery "at the least expensive rate and in the speediest fashion" because what counts in promoting learning is the "instructional method embedded in the media presentation" (p 26). Kozma (1994) argues that differences in media do affect outcomes but that the contribution of instructional method is also significant.

Thus, as universities rush to convert the delivery of education to newer and more flexible approaches, there is a pressing need to ensure that the materials being developed and delivered incorporate effective instructional methods. Problem Based Learning is an instructional method that has been successfully adopted in a variety of courses taught in face-to-face mode. This paper describes how it might be adapted as the basis for design of multimedia materials to be used in 'flexible delivery'.

2. INSTRUCTIONAL DESIGN FOR FLEXIBLE DELIVERY

Instructional design as an area of study emerged during a period when understanding of learning was based largely upon behaviourist theories of psychology. Although instructional design has since been influenced by other theories, its roots in behavioural theory are still evident (Willis, 1998). Early examples of computer based instructional systems embodied behaviourist principles and implementations of 'flexible delivery' which replace lecture presentations with online recreations of the same material appear to have similar roots. At their simplest such conversions may represent little more than electronic page turning although the better examples lead learners through a structured sequence of interactions which may include simulations and assessment in addition to presentation of core content.

In recent years the dominance of behaviourism as a basis for instructional design has been challenged by proponents of constructivist theory which offers an alternative view of how knowledge and understanding are developed (Willis, 1998). Savery and Duffy (1995) suggest that constructivism is underpinned by three propositions, namely, that understanding is inextricably connected with the interaction between learner and environment, that cognitive conflict or puzzlement is the stimulus for learning and that knowledge evolves through social negotiation.

Instructional systems based around constructivist principles are likely to be more suitable for learning in domains involving 'ill-structured' problems (Spiro, Feltovich, Jacobson, & Coulson, 1991). Such domains are likely to include large amounts of information and rather than a single right answer there may be several acceptable solutions (Voss & Post, 1988). Savery and Duffy (1995) identified eight instructional principles which emerge from their constructivist propositions and which might be used to guide constructivist design of learning environments. Further, they suggested that these principles are encapsulated almost ideally in problem based learning.

2.1 CHARACTERISTICS OF PROBLEM BASED LEARNING

Conventional approaches to university education are based on established subjects or areas of knowledge and have been criticised for encouraging teachers to focus on covering material and students to adopt surface learning approaches that fail to integrate knowledge across subjects (Margetson, 1994). Problem based learning (PBL) developed in response to concerns that a conventional subject-based approach to teaching did not provide the most effective preparation for future professionals who needed to access knowledge across a range of disciplines (Boud, 1985). Since PBL originated in North American medical schools it has spread to many countries and to a variety of fields including nursing, engineering, law and business (Boud & Feletti, 1991).

PBL typically involves an instructional sequence such as described by Boud (1985). It begins with presentation of a problem. Students then 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 developing 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 by Gibson and Gibson (1995) in which the first phase involved individual work. 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 problems or the sequence of learning activities, PBL implementations appear to share some common characteristics that have been summarised by Bridges (1992):

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 which 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.

Focussing on the solution of authentic problems as a context for learning accords well with theories of human expertise. For example, Dreyfus and Dreyfus (1986) noted that the performance of experts is frequently characterised by non-propositional knowledge. Hence, they suggested that beyond the initial stages of expertise development learning might be best achieved through sequences of situational case studies that included rich contextual information and afforded students opportunity for discussion and interpretation. PBL is an example of the application of these principles.

In its use of collaborative interaction among students for problem analysis and upon learner-directed research for gathering of content, PBL is the antithesis of the traditional teacher-directed lecture and tutorial system. Its supporters claim that it results in increased motivation for learning, better integration of knowledge across disciplines and greater commitment to continued professional learning (Boud, 1985). These outcomes are valued and PBL deserves serious consideration as an instructional design methodology for flexible delivery.

2.2 CHARACTERISTICS OF INTERACTIVE MULTIMEDIA

Multimedia is a generic term that can be applied to any form of presentation that combines multiple types of media (text, graphics, audio, animation, video). It is now generally assumed to refer to the combination of media under the control of a single computer program and this is how it should be understood in the context of flexible delivery. Interactive multimedia (IMM) is multimedia which goes beyond simple presentation to include provision for a degree of user control over progression through the material. The very simplest examples may involve little more than control over the rate of forward progress, a form of electronic page turning. More complex packages enable the user to take any of a very large number of alternative paths through material that may be both varied and extensive.

As a vehicle for flexible delivery, multimedia has much to offer. It allows large quantities of information to be made available for the use of individual learners at times and places of their choice. Material can be selected and arranged to include different representations of the content including the use of interactive components such as simulations and tests, thereby enhancing opportunities for the learner to develop a more thorough understanding. Well designed IMM packages have been demonstrated to be effective in promoting transfer of learning in complex knowledge domains (Jacobson & Spiro, 1995) which are commonly found in the professional areas towards which university courses are targeted. Where the material is delivered in the form of CD-ROM the unit cost of production after the initial development is relatively little and delivery can be readily extended to greater numbers of users.

IMM designs that incorporate a variety of access mechanisms leading to a rich array of content are appropriate for reference works from which users typically need to extract information related to a specific query. However, in an instructional setting such designs may work against deep learning by encouraging users to skim and sample from the content, even unwittingly missing critical components. If learners are to be encouraged to deep learning through engagement with the material then designs that promote this behaviour will be needed. PBL is such a design with a history of successful implementation in other delivery modes.

3. COMBINING IMM AND PBL

IMM and PBL could conceivably be combined in one of two ways. In the first, IMM materials might be developed to provide stimulus materials such as problem descriptions or resources to streamline the process of students locating necessary information within a conventional PBL framework. In the second, PBL might be used as the basis for design of the IMM materials so that all or most of a PBL experience could be encapsulated within the IMM package.

3.1 USING IMM TO SUPPORT PBL

Hoffman and Ritchie (1997) identified ways in which interactive multimedia might be used to support PBL. The key benefits they anticipated were fidelity, representational richness, time and timeliness, individualisation, assessment, efficiency and increased power of agency. Their analysis provides a solid foundation for using IMM to enrich PBL experiences.

Computer-based systems to support PBL approaches have been described for several specific areas of study. In one example from teacher education, a Problem Solving Assistant was used to support students through access to research resources and by use of an eight-step problem-solving heuristic (Ritchie, Norris, & Chestnutt, 1995). The Collaborative Learning Laboratory (Koschmann, Kelson, Feltovich, & Barrows, 1996) comprising seven linked computer workstations has been designed according to carefully articulated principles to support PBL meetings in medical education. It provides for data to be exchanged among participants as well as for access to a variety of resources.

Ronteltap and Eurelings (1997) have described the functional design of POLARIS, a proposed electronic learning environment for PBL. Their model is based upon explicit instructional design principles and incorporates both individual and collaborative learning environments. Students would work in the individual environment accessing resources and preparing materials

for presentation to the group through the collaborative environment. Since it is envisaged that the collaborative environment would support electronic interaction, it may not be necessary for groups to meet physically and the system could support the needs of distance or flexible learning.

Each of these applications offers to facilitate and enrich the experience of PBL. However, all are designed primarily to support existing collaborative approaches to PBL and do not propose the use of multimedia to facilitate flexible individual access to PBL experiences.

3.2 JUSTIFYING PBL AS A DESIGN FRAMEWORK FOR IMM

There are examples of IMM materials such as *Investigating Lake Iluka* (Harper, Hedberg, & Whelan, 1998) and *Exploring the Nardoo* (Hedberg et al., 1998) being successfully incorporated into teaching sequences using PBL principles. However, these packages do not explicitly rely upon a PBL framework and published examples of IMM packages that make explicit claims to use PBL as the instructional framework are difficult to locate.

The claim of PBL for consideration as an instructional design framework can be supported from self-efficacy theory. According to Bandura (1997), "perceived self-efficacy refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p 3). Such beliefs are the most central mechanism of personal agency through which people strive to control the events that affect their lives and have been shown to influence behaviour in a variety of fields.

Self-efficacy beliefs develop in response to four main sources of information (Bandura, 1997). The strongest influence is personal experience of success in the relevant domain, followed by vicarious experience that allows comparison with the attainments of others. A third source of influence is verbal persuasion that, if realistic, can encourage efforts that are more likely to increase efficacy through success. Finally, self-efficacy judgements can be affected by physiological and affective states such as stress.

IMM cannot completely substitute for personal experience but it may contribute to the second most powerful mechanism for increasing self-efficacy by providing learners with access to the recorded experience of experienced practitioners in a field. Such approaches are also supported by research that has demonstrated the potential for learning from examples for development of expertise (Chi & Bassok, 1989; Dreyfus & Dreyfus, 1986). The addition of a PBL framework with a potential to increase the engagement of learners beyond the point of simply observing examples might be expected to increase the potency of IMM for increasing self-efficacy which will in turn result in desired behaviours in future professionals.

3.3 THE INTEGRATING TECHNOLOGY INTO TEACHING PROJECT

The project described in this paper arose in the context of teacher education where it is becoming increasingly important that students be exposed to experiences that will prepare them to integrate information and communications technologies in their teaching. Previous papers have described the development process, the relationship of the project to current research in teacher education, and the design methodology (Albion & Gibson, 1998a; Albion & Gibson, 1998b; Gibson & Albion, 1997). This paper deals with those issues only briefly and focuses instead on some of the theoretical issues which underpin the design of the materials being developed.

Research suggests that although students have positive dispositions towards computer use, they lack confidence in their capacity to integrate technology in their future teaching (Albion, 1996; Downes, 1993) and that they may be responsive to examples of effective practice (Sherwood, 1993). Ideally students would encounter such examples and the opportunity for successful practice during field experiences. However, it is impossible to ensure that students doing field experience in different locations are exposed to uniformly good practice.

Hence the IMM package was conceived as a means of presenting examples of good practice in a matrix of supporting material. PBL was selected as the design framework in the expectation of increasing student engagement with the material and obtaining beneficial increases in self-efficacy as described above.

4. MEETING THE CHALLENGES OF IMM-PBL

Both IMM and PBL are sufficiently well established that they have built up around them conventions and expectations about how they should be implemented. Where those conventions and expectations differ it is inevitable that there will be some challenges and even tensions in achieving an appropriate combination.

4.1 COLLABORATIVE AND INDIVIDUAL LEARNING

It is clear from the PBL literature that there is widespread acceptance that collaborative work is a characteristic of the PBL approach. Whether collaboration of students in groups is an essential component of PBL logically depends upon the role that such group interaction plays in the overall experience of PBL. On the other hand, interactive multimedia is typically used by individuals, although prior or subsequent interaction related to the materials may occur.

Interest in exploring the possibility of providing PBL experiences for individual learners apart from collaborative settings may be justified on two grounds. Firstly, the professional practice for which PBL is intended to prepare students is situated in a variety of contexts including collaborative teams, sole practice in isolated settings and outright competition. Successful professional practice in many circumstances depends upon individual capacity to solve problems and educational experiences that develop that capacity should be valued. Secondly, the increasing interest in distance and flexible access to professional education renders desirable the possibility of providing rich PBL experiences in those modes.

The underlying propositions of constructivism (Savery & Duffy, 1995) include the ideas of cognitive dissonance and negotiation of meaning. Studies of student thinking during the initial problem analysis phase of PBL (De Grave, Boshuizen, & Schmidt, 1996) suggest that exposure to different ideas in the group leads to conceptual change. The group interactions serve to encourage activation and elaboration of existing knowledge and integration of alternative views. An IMM package based upon PBL principles would need to include a mechanism with equivalent effects.

In the present project each problem has been designed around the process of applying for a temporary teaching post which provides the context for dealing with a series of tasks related to technology integration. Each problem begins with an *activation* task in which the student responds to a selection criterion for the teaching position that is based on knowledge relevant to the later tasks but not directly related to the use of technology.

Rather than have the computer attempt to simulate group interaction, the design has incorporated a feedback mechanism through which after completing a task the student will obtain access to a collection of sample responses prepared by a group teachers who acted as consultants on the project. It is anticipated that exposure to a collection of varying responses in this way will have effects similar to interactions among a group of learners with differing interpretations of a problem.

4.2 FREE EXPLORATION AND SIMULATED REALITY

For many users, one of the attractive features of IMM is the ease with which they can navigate through the contents to access a variety of stimuli and resources. Freedom to explore is an underlying expectation of the medium. PBL requires goal directed behaviour towards solution of a problem. When the PBL experience is embedded in a simulated reality there may be restricted time available for exploration or, in imitation of the realities of professional life, selected resources may be inaccessible at certain times. Such restrictions are familiar to computer gamers. The construction of IMM-PBL challenges designers to balance these different sets of expectations.

The present project draws upon research that has demonstrated the efficacy of story for motivating users to progress through multimedia materials and for increasing transfer of learning from the materials (Bielenberg & Carpenter-Smith, 1996). Each PBL experience has been constructed around a simple story that begins with the learner applying for a teaching position and moves through a series of tasks that arise naturally in the context of the position.

Progress through the sequence is episodic. At each point where a task is set the user has access to resources linked from the consistent navigational metaphor of a teacher's desk. The transitions between tasks include graphic, video and audio material intended to provide a context for the problem and are generally delivered without input from the user.

Resources are grouped into two categories. *Static* resources such as general reference material presented as video clips or web pages are accessible any time the user is working at the desk. *Contingent* resources such as sample responses from consultants are made available as the story unfolds. Users are alerted as resources become available and those resources are subsequently available using links from the desk. It is anticipated that this arrangement will reduce the likelihood that students miss accessing important resources.

4.3 TUTORIALS AND SCAFFOLDING

Conventional PBL implementations assign a tutor or facilitator to assist students, mostly in the context of collaborative groups. Their role is not to inform but to model higher order thinking and to challenge the thinking of learners (Boud, 1985; Savery & Duffy, 1995). Providing this style of support presents a challenge to IMM-PBL design.

In the long run it may be possible to develop 'intelligent' software assistants that will be able to monitor user activity and respond appropriately. In the meantime support may be provided by including heuristic aids (Ritchie et al., 1995) or by decomposing problems into sub-problems (Savery & Duffy, 1995).

The project described in this paper has adopted the latter approach by presenting each problematic situation as a series of tasks (sub-problems) which are attempted in sequence with feedback in the form of model responses being provided after each task.

5. CONCLUSION

Problem Based Learning has already demonstrated its value as an effective approach to face-to-face learning in a variety of domains. Likewise Interactive Multimedia has been used as an effective delivery vehicle for a variety of content. The IMM-PBL combination is as yet unproven in operation but offers sufficient promise to warrant serious investigation. The *Integrating Technology into Teaching* project is breaking new ground by adapting PBL for use as the design framework in an IMM product. Evaluation data from user trials will be used to refine the present product and, more generally, to test the effectiveness of IMM-PBL as a flexible delivery model.

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