Evaluating the Implementation of Problem-based Learning in Interactive Multimedia

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Abstract

Interactive multimedia (IMM) which uses problem-based learning (PBL) as its underlying educational design has been developed for use in teacher education. The methods of evaluation used during the design and development of the materials are described. Although the completed IMM-PBL was clearly multimedia, the degree to which it was a valid implementation of PBL was less certain. This aspect was validated using an inspection method in which a panel of PBL practitioners reviewed the materials using a set of heuristics and rated the degree to which the materials implemented the PBL principles. The heuristics were based on published principles of PBL. Ratings and comments from the panel confirmed that the IMM-PBL materials constituted a valid interpretation of PBL.

Keywords

Heuristic evaluation, Inspection methods, Problem-based learning, Multimedia, Educational design

Introduction

Problem-based learning (PBL) first emerged in medical education in the mid-1960s (Norman & Schmidt, 1992). Since then it has spread to many different fields of professional education including nursing, engineering, law and business (Boud & Feletti, 1991) and has been promoted as making an important contribution to the reform of professional education (Margetson, 1994). The potential of interactive multimedia (IMM) for supporting and enhancing PBL has been recognised (Hoffman & Ritchie, 1997) and various projects in which IMM or other manifestations of IT have been used to support PBL have been described (Oliver & Omari, 1999; Pennell & Deane, 1995). PBL has also been used proposed as the

basis for design of IMM (Naidu, Oliver, & Koronios, 1998) and multimedia materials which would support the use of PBL as an educational approach have been developed (Hedberg et al., 1998).

Integrating Information Technology into Teaching (Gibson & Albion, 1999) represents an attempt to use PBL as the basis for educational design of IMM for use in teacher education. The underlying principles which guided the design of the interactive multimedia problem-based learning (IMM-PBL) materials (Albion & Gibson, 1998) and some of the challenges encountered in their development (Albion, 1999c) have been described previously. The IMM-PBL materials are accessed in a web browser environment and may be delivered on a CD-ROM or web server. They comprise a set of problem-based scenarios each of which present a series of tasks to be completed by the user.

So far as could be ascertained from a review of the literature, the application of PBL in this way as an educational design framework for IMM is novel (Albion & Gibson, 1998). There seemed no reason to doubt that the materials, which included text, images, audio and video presented in a web-based format, would qualify as multimedia. However, there is some debate as to what constitutes PBL (Barrows, 1986; Charlin et al., 1998) and its implementation has generally involved groups of students meeting with a tutor (Boud & Feletti, 1991). Thus, there were sound reasons for seeking to confirm whether the IMM-PBL materials would be recognised as a genuine implementation of PBL. This paper describes the approach taken to validating the claim that the IMM-PBL materials produced in this project represent a valid interpretation of PBL principles.

IMM-PBL Evaluation Framework

Development of the IMM-PBL materials occurred over a period of about two years and involved several evaluation strategies. These included relatively informal approaches such as the design team engaging in iterative walk-throughs of the scenarios as they were refined, the preparation and review of early screen designs and review of content by experienced teachers. The formal evaluation process comprised three stages, namely, a prototype test, beta testing and evaluation of the completed materials in the context of use.

The prototype test was used as a proof of concept and to obtain feedback about user preferences for content presentation and interface. A prototype

with limited interactivity was developed using content from one of the four scenarios planned for the final product. It was tested in use with a group of students drawn from the target user population and data was gathered using observations, interviews and questionnaires. Users were very positive about the overall concept, though not about all aspects of the implementation. Their comments on specific components were noted and used to inform subsequent development.

Beta evaluation was undertaken using an heuristic method (Albion, 1999a) based on previously published work (Nielsen, 1994; Quinn, 1996). Heuristic evaluation is one of a class of inspection techniques that are favoured for their cost effectiveness as a means of eliminating serious errors from software. Although the heuristic method was developed in the context of useability studies (Nielsen, 1994) with a focus on interface design, Quinn (1996) described an approach to applying similar methods to evaluation of educational design. The method applied to the IMM-PBL materials used the interface design heuristics described by Nielsen (1994) together with the educational design heuristics proposed by Quinn (1996) and, as advocated by Quinn, added heuristics for the evaluation of the content.

Evaluation of the completed IMM-PBL materials was undertaken in the context of use with intact classes. The criterion variable for the evaluation was self-efficacy for teaching with computers (Albion, 1999b). A pretest-posttest design with a control group selected from students in the same course but not currently studying the subject in which the IMM-PBL materials were used. Data from this evaluation confirmed that there was a statistically significant increase in self-efficacy for teaching with computers among users who had initially low self-efficacy for teaching with computers (Albion, 2000b). As well as these approaches to evaluation, two other methods were applied to the validation of the content and design of the IMM-PBL materials.

In the first of these methods, a significant portion of the content of the IMM-PBL materials was analysed to determine what messages about teachers' use of computers were being presented (Albion, 2000a). Results from this analysis confirmed that the messages in the content were consistent with the literature about appropriate practices in the educational use of computers. The second of these methods, which sought to validate the implementation of PBL in the IMM-PBL materials, is the subject of this paper.

Method

Although descriptions of PBL often include statements about the broad characteristics of the method, there does not appear to be a definitive statement that allows an easy distinction between what is PBL and what is not. One authoritative taxonomy of PBL (Barrows, 1986) proposed six variants of PBL spread along a continuum from lecture-based cases to more completely problem-based approaches. Clearly there is a substantial variety of approaches that might be acceptable as PBL but little clarity as to any criterion by which IMM-PBL might be included or not.

For practical purposes, what counts as PBL is determined by the community of PBL practitioners, who accept a practice or not. Hence, it was argued that IMM-PBL could be reasonably regarded as PBL if it was accepted as such by a group of experienced PBL practitioners. Such a group would need to review the IMM-PBL materials in order to form an opinion. Consequently, it was decided to use an inspection method of evaluation (Albion, 1999a; Nielsen, 1994; Quinn, 1996) similar to that used in the beta evaluation of the IMM-PBL materials and to develop the necessary set of PBL heuristics from published descriptions of the characteristics of PBL.

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)

Based on these sources, nine characteristics of PBL were identified and stated in a format suitable for inclusion in an instrument similar to that used previously for heuristic evaluation (Albion, 1999a). The statements are reproduced in Table 2. For the purposes of the evaluation they were presented with a rating scale on which respondents were asked to indicate the degree to which they agreed that the materials incorporated the relevant principle or characteristic of PBL. A five point scale (1 = strongly disagree to 5 = strongly agree) was used with an additional rating of NA for "Not Applicable". Space for comments was provided adjacent to each rating scale. The form also provided space for the respondents to identify themselves and to provide some indication of their experience with PBL.

Assembling a suitable panel of independent PBL practitioners presented a challenge. 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 brief description of the project and a URL where the project could be accessed. A link was also provided to an online version of the questionnaire that was set to e-mail data direct to the author

Results

Six responses were received from members of the PBL mailing list. Table 1 summarises the data that respondents entered in the space provided to record their PBL background and experience. References to specific universities and other identifying data have been removed or generalised.

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.

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.

Table 1: Experience cited by PBL practitioners' panel

Table 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".

It seems clear from the pattern of responses that the consensus is that the IMM-PBL materials match 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 although this 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 metaphor for navigation.

		SD 1	D 2	N 3	A 4	SA 5	Nil
1	The materials present a problem as the starting point for learning.				3	3	
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
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
4	The materials are consistent with an approach in which learners assume significant responsibility for their own learning.				5	1	
5	The materials would encourage learners to become active processors of information.				4	2	
6	The materials would provide opportunities for learners to activate prior relevant knowledge.				2	3	1

		SD 1	D 2	N 3	A 4	SA 5	Nil
7	The materials would provide opportunities for learners to elaborate and organise their knowledge.				4	1	1
8	The materials are consistent with an approach in which knowledge is organised around problems rather than disciplines.			1		4	1
9	The materials are consistent with the experience of learning in small groups rather than through lectures.		1	1	3		1

Table 2: Responses to PBL practitioners' questionnaire

Responses to the second item mostly included a comment 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 sample responses provided in the IMM-PBL materials (Albion & Gibson, 1998) 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 students might find 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.

Discussion

Although a panel of six practitioners might not be sufficient to sustain claims of statistical significance, it exceeds the minimum size recommended for panels of evaluators in heuristic evaluation methods to ensure identification of 75% of useability problems (Nielsen, 1994). 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 heuristics as listed in Table 2 are based on appropriate sources and their validity was not questioned by the practitioner panel. Inspection of the pattern of responses revealed that the raters generally agreed that the IMM-PBL materials implement the PBL principles. As noted above, the additional comments offered by the raters did not contradict the general agreement but did provide useful suggestions that might be applied to improving a subsequent version of the materials.

The only item to attract any disagreement 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. 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, 1998). 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. 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 consensus from this small, but knowledgable about PBL, group of respondents appears to be that the IMM-PBL materials match the listed characteristics of PBL derived from the literature. There was no suggestion that the principles were either incomplete or inappropriate. Thus it seems reasonable to conclude that IMM-PBL does qualify as a valid interpretation of PBL.

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