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EDUCATIONAL TECHNOLOGIES THAT INTEGRATE PROBLEM BASED LEARNING PRINCIPLES: DO THESE RESOURCES ENHANCE STUDENT LEARNING?

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Abstract

With the uptake of Problem Based Learning (PBL) as a popular curricular reform comes the challenge of creating and integrating educational technologies that dovetail with the philosophies underpinning PBL. The authors have created a computer program "Child Growth & Development in the first 12 months of life" to support the teaching and learning of this topic to medical students studying paediatrics. A PBL framework has been integrated into the educational design of the program. It was intended that by replicating the learning sequence of PBL and by providing strategies to overcome the individualised nature of computer programs in general, we could provide students with a tool that reinforced the PBL processes they were undertaking elsewhere in the curricula. Furthermore, by structuring content in a real life family context and encouraging students to be aware of the actual learning process, we aimed to stimulate student's motivation to learn more about child growth and development.

Keywords

Child growth and development, Paediatrics, Problem Based Learning (PBL), Medical education, Educational technology

Introduction

Problem Based Learning (PBL) is a curricular reform that is now widely used. Although first introduced in medical education in the 1960s, it is now pervasive in architecture, biochemistry, business administration, dentistry, economics, engineering, geology, law, nursing, optometry, social work and veterinary medicine education (Koschmann, Kelson, Feltovich & Barrows, 1996). In its ideal form, problems are used as a context for small groups of students to learn problem-solving skills and to acquire knowledge (Albanese & Mitchell, 1993; Koshmann *et al*., 1996).

The learning sequence of PBL generally involves the presentation of problem, small group analysis of problem and identification of learning objectives, hypothesis formulation, individual study and research, group sharing of findings and application to solving problem, and reflection where learning is summarised and integrated (Barrows, 1985). The emphasis of PBL therefore, is on self-directed learning: students both individually and as a group are largely responsible for their own instruction and learning (Koshmann *et al.*, 1996).

With the uptake of PBL comes the challenge of creating and integrating educational technologies that dovetail with the philosophies underpinning PBL. In a case study reporting on the integration of the computer program An@tomedia into a PBL medical curriculum, Kennedy, Kennedy and Eizenberg (2001) concluded that if designed appropriately, educational technologies could complement and support the PBL environment. This group highlighted flexibility as an inherent characteristic of the program that ensured its effectiveness. Highly interactive programs that target physiological concepts known to be difficult for students to understand such as baroceptor control of blood pressure, regulation of glomerular filtration rate and mechanisms of transepithelial transport have also been used successfully in a PBL medical curriculum as resources during the self-directed inquiry phase of the PBL process (Harris, Keppell & Elliott, 2002). These programs require students to use their knowledge and judgement to build realistic cell models, and are based on the constructivist theories of learning that align with PBL. However, neither of the examples described above were specifically designed to replicate the learning sequence of PBL, or to increase student's awareness of this process.

It could be argued that not all resources used within the PBL environment need to be designed according to principles of PBL. Books and journal articles, for example, stand alone as valuable supporting material. However, Harris, Keppell and Elliott (2002) point out that if computer-based resources used in the PBL environment are designed to replicate the PBL process they are less likely to "...undermine exploratory learning by presenting didactic expositions of core knowledge, or lead to a premature "solution" of the medical problem" (p. 27). Moreover, using PBL principles as a theoretical basis for the design of educational technologies reinforces the PBL processes that students undertake in PBL curricula. Barrows (1986) makes the point that the clinical reasoning process, for example, needs repeated practice to be perfected. Within this context therefore, the question that arises is whether student learning in PBL curricula can be enhanced by the use of educational technologies that integrate PBL frameworks that replicate and reinforce the PBL process?

Under the Melbourne/Monash Teaching and Learning Courseware Development Scheme, the authors developed a computer program *Child Growth & Development in the first 12 months of life* to facilitate the teaching and learning of child growth and development to medical students studying paediatrics. One of the main features of the program was the PBL framework integrated into its design. This paper describes the practical rationale behind the development, the theoretical models informing the educational design of the program, and discusses indicators of its effectiveness as a tool to reinforce the PBL processes that students undertake elsewhere in curricula.

Teaching and Learning of Child Growth and Development

For medical students undertaking a Paediatric clinical term at a teaching hospital (generally students in their fifth year of a medical course), an understanding of child growth and development (CG&D) provides a critical foundation for effective interactions with children during training and in their future careers. An important aspect of learning CG&D is the direct observation of young children. Unfortunately, very few opportunities arise for hospital-based students to observe and interact with well children over extended periods of time. This also makes it difficult for students to consider both the child-related and environmental influences on normal CG&D, and to integrate the many developmental changes that take place simultaneously in children.

In the past, some medical courses have offered a longitudinal child study in which students follow the growth and development of a real child over a period of one to four years (for example, the University of Melbourne's Longitudinal Child Growth and Development Follow-up Study and Monash University's

12 month Prospective Baby Follow-up Study). However, because of the resource intensive nature of these studies, logistical difficulties associated with their co-ordination, concerns about the variability of individual learning experiences, and the inability of experts to provide direction at the time of observation, many of these studies are no longer provided.

A computer program that allowed students to observe the progressive growth and development of the same child over time via the use of digitised video clips of the child performing age-related tasks and behaviours, offered an ideal solution to the difficulties associated with the teaching and learning of CG&D. The program that was subsequently created *Child Growth & Development in the first 12 months of life* was structured around six 'virtual' visits to a family with a new baby. Visits are made when the infant is 2 weeks, 6 weeks, 3 months, 9 months and 12 months old, to observe general aspects of the infant's growth and development. Other child health and family issues such as feeding, crying, immunisation, Sudden Infant Death Syndrome (SIDS), stranger anxiety, postnatal depression and anticipatory guidance are introduced to students during relevant visits.

The introduction of a PBL medical curriculum at the University of Melbourne in 1999 and the introduction of a case-based approach to teaching medicine at Monash University in 2002 reflected a change in teaching philosophy at these institutions towards a more student-centred style of education. The self-directed nature of the CG&D program integrated well with the objectives of these new curricula, and made it an ideal resource for students to use in their own time whilst undertaking the Paediatric term at a hospital. The program strove to find a balance between student's desire for and greater interest in a more 'clinical' experience, with the recognition that the underlying aim was for them to better their understanding of normal growth and development. Moreover, the design of the program whereby students deal with representations of complex, real life family situations reinforced the emphasis of providing a real life context for students to learn problem-solving skills.

Educational Design of *Child Growth & Development in the first 12 months of life*

The design of the learning sequence was based on a PBL framework and consisted of; presentation of problem, analysis of problem, formulation of hypothesis to explain problem, identification of individual learning objectives, further inquiry and data analysis, opportunity to reflect and refine hypothesis, decision-making or applying newly gained knowledge to the original problem, and finally prediction of future situations. Headings and labels were used throughout the program to highlight each step in the PBL process, in an effort to increase student's awareness of the actual learning process. This structure was repeated for every "virtual" visit that students made to the family and baby. Examples of each step and the educational rationale behind them are described below.

1. Scenario introduction

This motivates and sets the scene for students (see Figure 1). It also places learning within a realistic context, since it has been argued that meaningful learning will only take place if it is embedded in the social and physical context within which it will be used (Brown, Collins & Duguid, 1989).

Example: *"You are a recently graduated doctor. The enlightened hospital where you work understands the critical importance of child growth and development to all paediatric problems. Therefore, as part of your training, you are required to visit a family with a newborn baby at their home, six times over the first year at 2 weeks, 6 weeks, 3 months, 6 months, 9 months and 12 months"*

2. Problem introduction

A trigger video of a parent expressing concerns about their child introduces the problem to students (see Figure 1). Authentic triggers have been shown to be capable of immersing students in a problem, and of creating a mind set that allows students to approach a problem as if it were a real life situation (Elliott & Keppell, 2001).

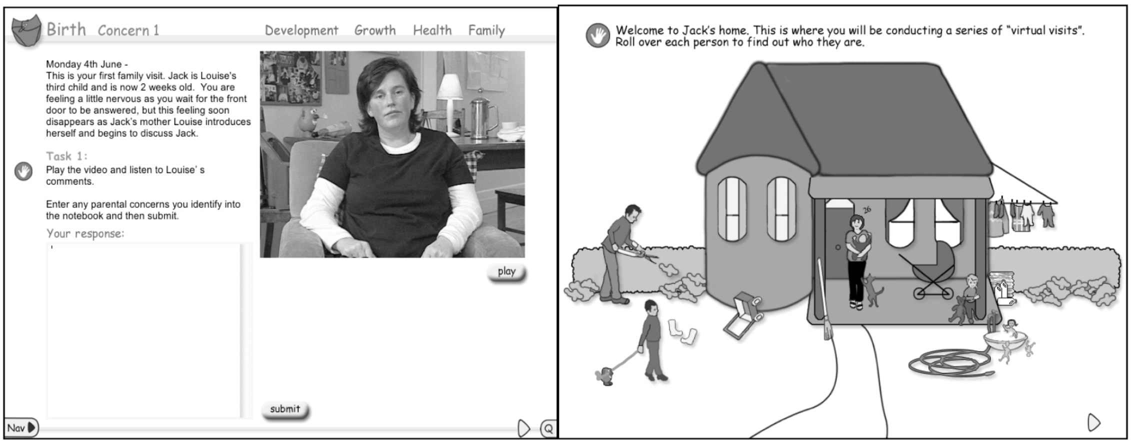

Figure 1:Problem introduction & Scenario introduction

3. Problem definition

Students analyse the trigger video and then identify the problem that needs to be solved. On submitting their response they are provided with an expert's response to the same question, thereby allowing them to compare their own response to an expert's. We considered this to be an activation task (to activate student's prior knowledge) in lieu of the small group interactions typical of PBL methods because it allowed students to consider or integrate another view (Albion & Gibson, 1998). By asking students to record this information we were attempting to increase their awareness of the consultation environment, including note taking, as in the case of recording patient medical histories.

Example: *"...listen to the mother's concerns. Enter any parental concerns you identify into the notebook..."*

4. Hypothesis formulation

Students use their prior knowledge to attempt to explain what is going on. Again, in an effort to counter the lack of group interaction at this point of the learning sequence, feedback was provided in the form of expert responses that students could compare to their own response.

Example: *"Enter any possible hypotheses you have about what factors could be causing, contributing to, or influencing the parental concerns into the notebook"*

5. Inquiry

The formulation of a hypothesis allows students to recognise gaps on their knowledge and enables them to identify their individual learning needs. Students then explore the additional resources provided in the program to seek further information.

Example: *"You may wish to consider additional background information to help you formulate your hypothesis"*

Students were provided with a rich variety of resources to assist the learning process (Wilson, 1996). Each visit contained an age related library of resources organised under the headings of Development, Growth, Health and Family, which included reading text, images, video, tasks and URLs to relevant web sites. Students could access these resources at any stage in the program to gather information regarding normal growth and development, child health and family issues. A video library of movies showing a selection of developmental skills at different ages was also available. Some of these movies were incorporated into the problems that students worked through - others were additional resources.

6. Data analysis/Gather further information

Students are encouraged to narrow the focus of their inquiry, having been provided with additional information such as the child's medical history, weight/length information and results of an examination.

Throughout the program, when students are asked to submit a task they are provided with an expert's response to compare to their own.
Example: *"In order to refine your hypothesis you need to know about the normal variation in infant feeding and crying behaviour"*

7. Refine hypothesis/Reflection
The additional knowledge that students have gleaned during their searching allows them to restructure their understanding of the original problem.

8. Outline advice/Decision making
Students apply the results of their learning to decide on the most appropriate advice to give the concerned parents. Outlining advice to parents about their child is an authentic task that students will encounter in their future profession as doctors or paediatricians. Proponents of situated cognition theory believe that it is important that activities reflect the way knowledge and skills will be used in future practice (Herrington & Oliver, 1995).
Example: *"Outline your advice (to the parents)..."*

9. Provide anticipatory guidance
Students make predictions about future guidance for parents. Again, this is an authentic task where students are asked to provide information to the parents on age-related health promotion and disease prevention.
Example: *"Having responded to the mother's concerns with your advice, you are then expected to provide her with anticipatory guidance relevant to the child's age"*

Critical Characteristics of PBL Design

Although the term PBL is often used in the literature to describe a specific educational method, there are in fact many different variations. This prompted Barrows (1986) to devise a taxonomy of PBL methods based on (i) the design and format of the problems used in PBL (complete case, partial problem simulation or full problem simulation-free inquiry), (ii) the degree to which learning is teacher-directed or student-directed, and (iii) the degree to which each of the four educational objectives (listed below) are addressed by the educational design. Each objective in the last criterion is estimated by a score of 0-5 and justified by a brief narrative. The four important objectives referred to are:
1. Structuring of knowledge for use in clinical contexts (SCC)
2. Development of an effective clinical reasoning process (CRP)
    - Hypothesis generation
    - Inquiry
    - Data analysis
    - Problem synthesis
    - Decision making
3. Development of effective self-directed learning skills (SDL)
4. Increased motivation for learning (MOT)

Barrows (1986) goes on to suggest that the opportunity that students have to work in parallel with real patients and the quality of the facilitator are additional variables that can influence the outcomes of PBL.

Barrow's taxonomy was used to determine how well the CG&D program aligned with PBL methodology. According to his taxonomy the design of the program is described as follows:
Modified case-based: In this method the content is structured for use in an authentic context, thus giving a SCC score of 4.0 (methods such as case-based, for example, score a rating of 3.0). The cueing and restricted inquiry of the program (students have a limited number of resources to explore) prevent a full score for CRP. However, students do apply the results of their learning when deciding on appropriate

advice to give to the parents, and when predicting future guidance for parents, therefore, the CRP could be conservatively raised to a score of 3.5. The program is designed to address SDL but is only given a score of 3.0 because students do not know what additional information they might need if they had to carry out the full and free inquiry. Also, the program contains a restricted set of resources that have been chosen by experts. This method is regarded as highly motivating, scoring a rating of 5.0 (see Table 1).

Educational objectives and corresponding score			
SCC: 4.0	CRP: 3.5	SDL: 3.0	MOT: 5.0

Table 1: Attributes of the "Child Growth & Development in the first 12 months of life" program estimated according to Barrow's taxonomy (1986).

The CG&D program could not be described as a partial problem simulation, where students are given the initial presentation of the problem and have to assemble relevant information through free inquiry (even though a number of the facts are provided) because the program design did not allow for total, free inquiry.

Evaluation

Initial evaluation was undertaken to determine the general useability of the CG&D program, including aspects of interface design, navigation, interactivity and structure. We also wanted to ascertain student's perceptions of their understanding of the subject matter prior to attempting the program and again after completing it. Three current medical students (either 4th or 5th year) went through the program individually, completed a questionnaire, and then participated in a focus group to express their thoughts and opinions about the CG&D program.

Evaluation data indicated that the aims of the program were clear and that students knew what was expected of them at the beginning of the program. Responses relating to the structure of the program did not indicate any problems with the organisation of content, identification of important information or key concepts, or explanation of concepts and issues. However, one participant (Student A) found the sequencing (or flow) of information from screen to screen confusing. Student A also raised concerns about the navigation, *" (there was) too much clicking around - should be more continuous, less navigation"*, and when asked specifically about the navigation remarked, *"I would have been happy to have just had a button that I could click and go through the resources one after the other (referring to a linear structure)"*. Student A consistently rated the program lower than the others in relation to the following characteristics; engaging, appeal, user friendliness, enjoyable and logical.

In terms of aspects of the program that were most valued by user's, Student A liked the extensive use of video to demonstrate different temperaments and behaviours of children, and the real-life family approach, but unlike others failed to consider aspects such as the PBL style or the expert responses. When asked directly about the value of the PBL, Student A commented, *"I didn't know what you meant when we were asked to enter a possible hypothesis. I didn't know if I had to just reword the problem"*. The other participants didn't have difficulties entering hypotheses, *"I knew what you meant"*. In fact, they felt that the PBL approach encouraged active participation in the program, *"The PBL style/approach encourages engagement. A much better design than "static" CALs (Computer Aided Learning programs) or those sessions with CALs and worksheets with questions"*, and were not concerned about the exploratory style of the program. Furthermore, they regarded the expert responses as highly valuable feedback, *"The expert responses were very helpful, particularly in outlining a thorough approach to the presenting problems"*.

In relation to user's perception of their understanding of the subject matter prior to, and after completing the CG&D program, Student A indicated no change in understanding of child development, ability to evaluate a child's level of development, or understanding of child health issues. In terms of the subject matter, Student A noted that there was *"not enough emphasis on the core topics eg. milestones, immunisations, growth charts"*. This was in contrast to the other participants who perceived an improvement in understanding of all these areas after using the program. Nevertheless, one of these users also stated, *"The package focuses on the PBL style of problems and the GP consultation environments which is good, but may in part detract from learning about normal stages of growth and development, which I seemed to only get a feel for through the "filling in the gaps". (Maybe) more upfront emphasis on the routine physical exams done at each development stage (is needed)?"* The "filling in the gaps" section was designed to alert students to relevant material that they may have missed during their self-directed inquiry of the resources.

A consistent trend began to emerge from this information that highlighted a discrepancy in user attitudes toward the learning method employed in the program. It may be that this is simply a reflection of individual users preferred learning style. However, Student A did not appear to be as comfortable with, or have the same expertise as the others with the self-directed, exploratory style of the program. Moreover, student A did not seem to be aware of the learning processes used in the program or the function of the expert responses. This was remarkable, considering that student A was more experienced being a 5*th* year medical students who had already completed a Paediatric clinical term (although this may explain why no change in understanding of the subject matter was perceived).

A major difference that might explain these observations is the type of curriculum that students were enrolled in. Student A was in the last year of the traditional medical curriculum, while the others were 4th year students currently undertaking a PBL medical curriculum. The former users would have had more experienced with PBL processes, having undertaken weekly PBL sessions during the earlier years of their course. This highlights the advantage of using resources that integrate PBL frameworks to reinforce PBL processes, and as a means of enabling students to practise their evidence-based reasoning skills. It also appears that such programs encourage more investigative and independent approaches to learning.

Conclusions

According to Barrow's taxonomy the *Child Growth & Development in the first 12 months of life* program aligns well with PBL methodology. It's design is described as a modified case-based approach with an estimated score of SCC: 4.0, CRP: 3.5, SDL: 3.0, MOT: 5.0. This is higher than lecture-based cases which typically score SCC: 1, CRP: 1, SDL: 0, MOT: 1, but lower than the ideal situation of closed-loop, problem-based methods with a maximum score of SCC: 5, CRP: 5, SDL: 5, MOT: 5.

One of the major strengths of PBL is the small group analysis of problems that promotes activation, and elaboration of prior knowledge (Schmidt, 1993). Small group interactions are difficult to replicate within the structure of computer-based programs. The tension between the emphasis of PBL on small group interaction and the individual nature of computer-based programs has previously been highlighted by Albion and Gibson (1998). Although variations of PBL have been described in which the first phase involves individual work (Gibson & Gibson, 1995), we have integrated alternative strategies into the program such as the use of activation tasks to demonstrate alternate views, and the decomposition of problems into a series of tasks (or sub-problems) that students attempt in sequence with feedback in the form of expert responses being provided after each task (Albion & Gibson, 1998).

Currently, the CG&D program is being used as a self-directed resource for students to use in their own time whilst undertaking the Paediatric term at a hospital. The benefit of small group interactions could be gained if groups of 3-4 students were encouraged to complete the program together. However, time schedules and student numbers at each hospital may make this an impractical way to implement the program.

The integration of a PBL framework into the CG&D program was beneficial in terms of reinforcing and allowing students to practice their clinical-based reasoning skills. Feedback also suggests it increased students awareness of the actual learning process, which is thought to encourage active participation in knowledge construction by learners. Whether this enhances overall student learning in a PBL environment is still unclear. Indirectly, these factors may contribute to increase student's motivation and desire to learn more about child growth and development. However, further detailed evaluation is required to determine the direct effect of these types of educational technologies on knowledge acquisition and clinical skills in PBL curricula. The comment by one of the focus group students about PBL approaches encouraging clinical skills on one hand, but at the same time detracting from learning about child growth and development, suggests that while student learning may be enhanced at one level (clinical skills) it may not be on another (knowledge acquisition).

References

Albanese, M. A., & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. *Academic Medicine*, 68 (1), 52-81.

Albion, P. R., & Gibson, I. W. (1998). Designing multimedia material using a problem-based learning design. In R. M. Corderoy (Ed), *Australian Society for Computers in Learning in Tertiary Education. Ascilite'98 Conference Proceedings*. (pp. 39-47). University of Wollongong, NSW.

Barrows, H. S. (1985). *How to Design a Problem-based Curriculum for the Preclinical Years*. New York: Springer Publishing Company.

Barrows, H. S. (1986). A taxonomy of Problem-based learning methods. *Medical Education*, 20 (6), 481-486.

Brown, J. S., Collins, A. & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, 18 (1), 32-42.

Elliott, K. A., & Keppell, M. (2000). Visual triggers: Improving the effectiveness of virtual patient encounters. In R. Sims, M. O'Reilly and S. Sawkins (Eds.), *Australian Society for Computers in Learning in Tertiary Education. Ascilite 2000 Conference Proceedings*. (pp. 275-283). Southern Cross University, NSW.

Gibson, I. W., & Gibson, K. L. (1995). A window into the rural classroom: interactive television and problem-based activity in Australian pre-service teacher education. *Journal of Information Technology for Teacher Education*, 4 (2), 217-226.

Harris, P. J., Keppell, M., & Elliott, K. A. (2002). Integration of multimedia in the Problem-based learning curriculum. *Journal of Medical Education (Taiwan)*, 6 (4), 24-30.

Herrington, J., & Oliver, R. (1995). Critical characteristics of situated learning: Implications for the instructional design of multimedia. In J. M. Pearce & A. Ellis (Eds.), *Australian Society for Computers in Tertiary Education. Ascilite'95 Conference Proceedings*. (pp. 253-262). University of Melbourne, Australia.

Kennedy, G. E., Kennedy, D. M., & Eizenberg, N. (2001). Integrating computer facilitated learning resources into Problem-based learning curricula. *Interactive Multimedia Electronic Journal of Computer Enhanced Learning*, 3 (1). http://imej.wfu.edu/articles/2001/1/02/index.asp

Koschmann, T., Kelson, A. C., Feltovich, P. J., & Barrows, H. S. (1996). Computer-supported problem-based learning: A principled approach to the use of computers in collaborative learning. In T. Koshmann (Ed), *Computer Supported Collaborative Learning: Theory and Practice in an Emergency Paradigm*. (pp. 83-124). Mahwah, NJ: Lawrence Earlbaum.

Schmidt, H. G. (1993). Foundations of problem-based learning: Some explanatory notes. *Medical Education*, 27, 422-432.

Wilson, B. G. (1996). What is a constructivist learning environment? In B. G. Wilson (Ed), *Constructivist Learning Environments: Case Studies in Instructional Design*. (pp. 3-10). Educational Technology Publications Englewood Cliffs: New Jersey.