PROBLEM BASED LEARNING AND MULTIMEDIA: INNOVATION FOR IMPROVED LEARNING OF MEDICAL CONCEPTS

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ABSTRACT

The curriculum of the medical course at The University of Melbourne is currently being transformed from a traditional discipline-based approach to an integrated, body systems teaching program incorporating elements of Problem Based Learning (PBL) and Information Technology (IT). This paper describes our experience with the use of interactive multimedia teaching modules and clinical-based scenarios to teach medical related concepts and principles. It examines: (1) educational context, (2) curriculum development processes, (3) mode of delivery, (4) design and development of resources and, (5) future directions. An important aspect of our approach is the emphasis on interactive CAL modules which address content areas in which staff or students have identified educational difficulties. Because of the guided nature of this approach involving clinical based reasoning these represent Directed Self-Learning (DSL) modules rather than Self-Directed Learning (SDL) modules.

The integrated structure of the new medical course will encourage students to relate knowledge across years and between disciplines. Early clinical relevance and exposure will be achieved by the provision of teaching material that simulates actual clinical situations. These computer based 'problems of the week' will act as a trigger for student investigation of a medical condition and the underlying causal factors. Small groups of students will be guided by a tutor towards a set of learning objectives. Lectures, practical classes and self-directed learning resources will be used to reinforce these objectives.

The design and development of the 60 'problems of the week' required for semesters 1-5 of the new course, and the interactive multimedia teaching modules needed to support approximately 100 weeks of the new course, will be managed by the Biomedical Multimedia Unit (BMU). This involves conceptual design, graphic design, programming, evaluation and implementation into a learning framework for delivery within an intranet based multimedia laboratory. Future directions include remote access of learning material by medical doctors for continuing education.

KEY WORDS

Problem-based learning, multimedia design & development, project management, medicine.

1. INTRODUCTION

Traditionally, the MBBS course at The University of Melbourne has been taught using a discipline-based approach. In the early years of the course, students undertook discrete subject blocks from the pre-clinical departments of Anatomy and Cell Biology, Biochemistry and Molecular Biology, Microbiology and Immunology, Pathology, Pharmacology and Physiology. These subjects represented a core of scientific knowledge that was progressively built upon as students undertook more advanced levels of study. Exposure to clinical scenarios *in situ* came later in the course (predominantly years 4-6), after students had gained an understanding of the basic sciences relevant to medicine.

Internal review mechanisms and student feedback in recent years highlighted a number of deficiencies in the traditional course; insufficient integration between basic and clinical science, insufficient attention to communication skills, problem solving skills and social aspects of health, an overload of detail and, unnecessary duplication of content. In an effort to address these problems and to incorporate current theories of medical education, a new medical curriculum will be introduced having an intake of school leavers and graduates.

The pedagogical model for the new medical curriculum incorporates elements of Problem Based Learning (PBL) and Directed-Self Learning (DSL). The primary focus of learning in Semesters 2-5 will be medical problems (referred to as 'problems of the week') which will be presented to students in small group tutorial settings. Ten students will be guided by a trained PBL tutor towards a set of learning objectives and will then be encouraged to direct their own learning and to seek out information from various learning resources, in order to define, resolve or manage the medical problems. Several didactic forms of teaching such as lectures, practical classes and dissections will be retained where appropriate.

Key features of the new curriculum will be the horizontal integration across disciplines and the vertical integration of clinical situations with basic scientific material. The framework for this integration during Semesters 2-5 will consist of the major systems of body functions (Body Systems). This will enable students to relate knowledge across years and between disciplines. Also in the new course, students will have early exposure to clinical situations; from Semester 1 students will learn in clinical out-placements. Another component of the curriculum examines the integration of clinical medicine, human mind and behaviour and health and society throughout the curriculum. The use of Information Technology (IT) will be an important feature of the new curriculum.

The overarching goal of the new course is to produce graduates who are independent, life long learners who will continue to develop knowledge and skills throughout their career. More specifically, the graduates will have developed the necessary skills (communication, history taking and physical examination) and attitudes to allow them to practise high quality, ethical and scientifically-based health care.

2. PROBLEM-BASED LEARNING (PBL)

This section defines the nature of PBL and discusses the theoretical principles which form the psychological and educational foundations of this approach. Such an analysis of PBL is essential to understand the role of IT in the new curriculum and the design and developmental approach taken by the Faculty of Medicine, Dentistry and Health Sciences (see Section 4).

The elements of PBL used in the curriculum involve case based reasoning whereby students solve hypothetical clinical problems in small groups under the guidance of a tutor. Vernon and Blake (1993) define PBL as a "method of learning (or teaching) that emphasises (1) the study of a clinical case either real or hypothetical, (2) small group discussions, (3) collaborative independent study, and (4) hypothetical deductive reasoning" (p. 550).

A more comprehensive definition of PBL is forwarded by Schmidt (1993). He suggests that PBL is based on cognitive psychology principles such as "prior knowledge activation and elaboration through small-group problem analysis; the construction of problem-oriented semantic networks, including contextual cues derived from professionally relevant problems: and the fostering of epistemic curiosity" (Schmidt, 1993, p.427).

Central to Schmidt's (1993) definition of PBL are issues such as: (1) prior knowledge, (2) activation of prior knowledge, (3) elaboration of content, (4) restructuring of semantic networks/ schemata, (5) development of an intellectual scaffold, and (6) motivation. To explain the psychological and educational rationale of PBL, each of these terms will be discussed in turn.

2.1 PRIOR KNOWLEDGE

In the context of medical education, PBL attempts to immerse students in the process of solving a clinical problem. The first step in this process is to examine the learner's existing or prior knowledge. Schmidt (1993) suggests that the extent of prior knowledge in relation to a subject is one of the major determinants of the "nature and amount of new information that can be processed" (p. 424). The importance of prior knowledge and learning has also been stressed by Ausubel (1968) who states that knowledge is acquired when it is meaningfully related to, and subsumed under, an already existing concept or body of knowledge. The essential factor in the acquisition of knowledge is that content must be linked to what is previously known.

2.2 ACTIVATION OF PRIOR KNOWLEDGE

Under the guidance of the PBL tutor, an exchange of ideas between participants of the PBL session assists in activating the prior knowledge of students. This exchange needs to occur before further learning resources are investigated by students. The discussion has the effect of creating a 'learner readiness' for subsequent stages of learning by asking the students to generate hypotheses for the problem.

2.3 ELABORATION

The storage and retrieval of information is said to be enhanced when elaboration of the material takes place (Schmidt, 1993). In the medical context this elaboration of the content by the individual student takes the form of listening to other student's hypotheses in relation to the 'problem of the week' and determining the merit and worth of these different diagnoses. The cognition involved in recognising the merit and worth of these different perspectives begins the process of elaboration.

The use of additional learning resources in the form of journal articles, books, multimedia teaching modules and relevant web-sites will further elaborate student learning. A second round of PBL discussions at the weeks end will also allow students to obtain a more in-depth and differentiated understanding of the problem.

2.4 RESTRUCTURING

The cognitive networks which are restructured during learning are referred to as schemata. Gagne (1986) defines schemata as "a set of interconnected propositions centering around a general concept, and linked peripherally with other concepts". Depending upon the existing knowledge of the student, a process of accretion, tuning or restructuring occurs to actively change existing schemata. Schemata are not static but continually evolve in content and structure. When new learning occurs, new schemata develop or old schemata undergo structural changes. When more information is incorporated into an existing data structure *accretion* is said to occur (Gordon & Rennie, 1987, p. 163). The existing data base does not change in form but is built upon. *Tuning* refers to the adjustment of existing data bases. The continual tuning or minor modification in categories of interpretation (schemata) occurs to bring the categories more in congruence with the functional demands placed on them (Gordon and Rennie, 1987) (p. 163). *Restructuring* is an important process for changing existing schemata or developing new schemata. It involves a difficult learning process and does not occur easily. New schemata must be devised to interpret new information, or old schemata may be re-formulated (Keppell, 1997, p.42).

This concept of restructuring may have important implications for medical students who are unable to apply their basic scientific knowledge to clinical situations. It has been suggested that the knowledge of these students have not yet been organised into a manner which can be utilised for this function (Schmidt, 1993).

PBL attempts to address the relevance of content within the specific medical context. The PBL session assists in tuning students knowledge (Schmidt, 1993). This restructuring of existing schemata is also a powerful means of strengthening the retrieval of the information through contextual cues contained in the trigger sequence of the problem. The concept of situated cognition explains why this may be the case; learning is a process of enculturation. In this instance, the medical student is being enculturated into the process of diagnosing a clinical case. The PBL session allows this enculturation to be further reinforced by providing authentic activity. This is one way that medical students gain access to the standpoint that enables practitioners to act meaningfully and purposefully (Brown, Collins and Duguid, 1989).

2.5 SCAFFOLDING

In the process of PBL the student will develop a framework for use with subsequent problems of the week. Ausubel (1960) referred to this framework as an intellectual scaffold. Intellectual scaffolding is an infrastructure of information to which new material can be anchored (Ausubel, 1960). By beginning a task embedded in a familiar activity, it demonstrates to students the legitimacy of their implicit knowledge and its availability as scaffolding in apparently unfamiliar tasks (Brown, Collins and Duguid, 1989, p. 38).

2.6 MOTIVATION

The negotiated meaning that occurs through discussion in the PBL session also attempts to foster the motivation of the student. The medical student will be intrinsically motivated to find out more about the case being examined; indeed PBL attempts to foster life long learning.

2.7 USE OF PROBLEM OF THE WEEK IN PBL

The application of PBL at The University of Melbourne is described below; its focus is on a specific problem for each week of the curriculum, throughout semesters 2-5.

The Problem of the Week (POW) begins with the ‘trigger’. The aim of this photograph or video sequence is to set-the-stage for the student by providing a visual of the hypothetical patient and the circumstances surrounding the scenario. The trigger instils a “suspension of disbelief” by immersing students in a problem as if it were a real clinical case. This visual stimulus provides the context without providing a definitive explanation for the medical condition of the patient.

Following the trigger, students are instructed to list information about the patient, identify the presenting problems, list possible causes of each problem (hypotheses), provide a rationale for each hypothesis, prioritise the list of hypotheses and then determine what other additional information (physical examinations, laboratory tests, etc) is required to differentiate between the hypotheses.

During this process students are given supporting information in the form of a history, past medical history, physical examination, progress, investigation results, closure and self assessment items. A progressive release of information guides the student in formulating hypotheses about the medical condition; after the first tutorial at the beginning of the week the student investigates the resource list consisting of articles, books, images or exhibits, posters, CAL packages and WWW sites. Armed with additional information the student returns to the second tutorial at weeks end to discuss the more plausible hypotheses behind the medical condition of the hypothetical patient.

3. INFORMATION TECHNOLOGY

The use of Information Technology (IT) will be an important feature of the new curriculum. Computer-based teaching materials will be delivered primarily utilising the Internet (World Wide Web) and an Intranet, however, CD-ROM will also be used to enable students to access image-rich resources from home. The Problem of the Week, along with the accompanying list of learning resources for that week will be delivered to students in a tutorial setting over the Web. Some of the learning resources such as appropriate Web sites, image banks, practical

experimental simulations, self-assessment tests and multimedia teaching modules will be accessed via the computer. Other resources, such as readings from text books, journals and articles, posters and specimen exhibits will be available from traditional libraries and museums. Figure 1 outlines the components of the medical curriculum and illustrates which areas utilise IT.

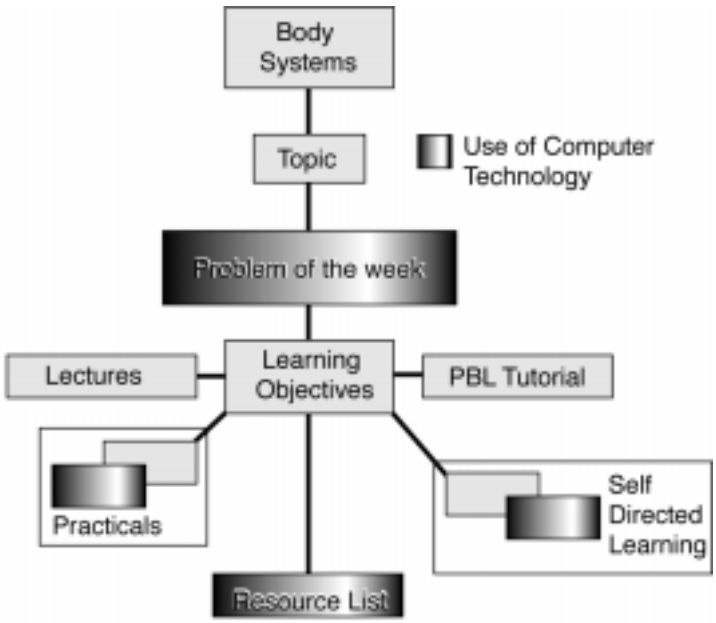

Figure 1: IT Components of the Medical Curriculum

Multimedia teaching modules will be used extensively in the new course as learning resources in areas that students have traditionally had difficulty understanding or in areas where the use of media, such as video, audio or animation is particularly appropriate to demonstrate a concept or principle. The emphasis of these teaching modules will be on interactivity rather than electronic textbook style. Modules will either have been developed in-house specifically for the new curriculum or obtained from outside sources if they appear to be useful and fulfil a need. At present, the BMU is involved in the design and development of approximately 20 multimedia modules being produced within the Faculty of Medicine, Dentistry and Health Sciences to support topics in the new curriculum (see Section 4).

The delivery of computer based materials will be facilitated by TopClass, a Web based software package used to organise, co-ordinate and manage materials. The TopClass Learning Framework will provide a shell into which computer based resources are placed; sections include course work, self assessment tests, class announcements, discussion lists and messages. The Learning Framework will also provide a central access point for students to enter the on-line course work (Problems of the Week), to participate in structured discussion groups or to send messages to teachers or peers.

As outlined previously, a number of different teaching strategies are being utilised to deliver the new medical curriculum, only one of which is based on IT. As such, computer based learning will complement but not replace traditional modes of learning. Computer based materials will be used to resolve educational issues rather than using the technology just because it is available; for example, when dealing with tiredness the body language and emotion of a patient's response is as important as the patient's verbal response. Video is an ideal medium to capture these characteristics and portray them to a student using video online, CD-ROM or streaming video from a server. Also, concepts and principles that have traditionally caused students difficulty are areas that are likely to benefit from a change in teaching approach and which could be enhanced through the use of computer based learning.

One of the advantages of using computers to deliver Problems of the Week is that the trigger sequence which introduces students to the medical condition, could be a piece of video or audio. When visual or audio cues are important, these types of media are far more descriptive than a still graphic or a paragraph of text. Another advantage is that all the learning resources associated with a particular problem are listed in one place, making it easier for students to seek out further information during the DSL component of the course. Also, such learning resources as Web sites and multimedia teaching modules can be accessed by students from either the computer laboratories, home or other remote sites. This allows greater flexibility for DSL and allows the student more freedom in their personal time-management.

4. DESIGN AND DEVELOPMENT

The shift in philosophy for the new medical curriculum has major implications for: (i) design and development of computer based learning resources, (ii) access of resources from the learning framework, and (iii) organisation of the computer laboratory for DSL by students.

For the new curriculum about 160 problems of the week will have to be created, and approximately 80 multimedia teaching modules are required to support topics in Semesters 1-5 and 8-12. During 1998, the design and development of 18 problems and 20 multimedia teaching modules was undertaken within the Faculty of Medicine, Dentistry and Health Sciences. In conjunction with department based multimedia groups, three Units are involved in this process. The relation between these units are shown in Figure 2.

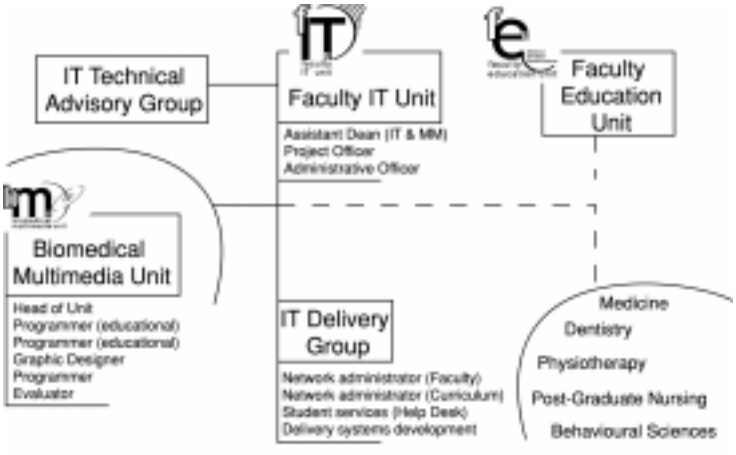

Figure 2: Organisational Structure – IT and Multimedia – Faculty of Medicine, Dentistry and Health Sciences

The Faculty Education Unit (FEU) works directly with clinicians and academics. These individuals are organised into task groups to develop content for different topics within the new curriculum, and into Problem Coordinating Teams (PCT) to develop content for the Problems of the Week. This unit combines medical and curriculum development expertise to develop the new curriculum.

The Faculty Information Technology Unit (FITU) consists of three staff members and liases between the FEU and BMU to ensure that the content of the multimedia resources being produced under the management of the BMU is in line with content being developed by the FEU. The unit also co-ordinates information exchange sessions in this area and oversees two staff involved in network administration and lab administration. The Biomedical Multimedia Unit is a sub-unit of the FITU and currently employs six staff and three contractors and includes instructional designers, graphic designers, programmers, a multimedia evaluator and learning framework specialist. The role of this unit is to assist the FEU with the conceptual and interface design of the Web deliverable Problems of the Week and to translate the written content into HTML documents. It also oversees the design and development of multimedia teaching modules, and provides evaluation services.

The process of determining and collecting content has been developed into two concept maps: one describing the general strategy for the production of the Problem of the Week, the other describing the production schedule for 1999. Fundamentally the process involves the development of content by the PCTs who determine the type of problem relevant to a particular week of the curriculum. This content is collated using a content template and then transferred into a Pagemaker template for the production of PBL tutorial handouts for students. Content is then entered into an HTML template developed by the BMU to directly complement the learning framework.

A comprehensive project management plan was developed to manage some 20 projects currently being undertaken by staff within the Faculty. This plan outlines a 12 month schedule and provides milestones and stages for completion of projects. It details questions to ask at initial meetings and suggests dates for completion of conceptual design, interface and graphic design and programming as well as both formative and summative evaluation. Completion of progress reports are encouraged at various milestones throughout the schedule. The culmination of this schedule is a symposium, where the multimedia teaching modules will be presented to other members of the university community.

The project management process was developed to handle various logistics related to each project. A Project Management Taskforce, consisting of BMU and FITU staff was set up, and each member of this taskforce acts as a contact point for different projects. Each of the 20 projects involve different groups, working with different resources to support different areas of the curriculum. The BMU provides different services for each project. Projects may require advice on concept mapping, planning grids (Keppell & Buschgens, 1995) interface design, multimedia authoring, formative and summative evaluation, and project management. To assist with future initiatives by individual project holders an informal process of client education (on multimedia design and development) has commenced. The generic development process was presented to project holders in a seminar, and then distributed in the form of a checklist which could be used for development of their project. Some projects follow this general process whereas others use their own model. Seminars on evaluation have also addressed the educational and pedagogical value of each project.

Fundamental to the entire management approach is an understanding of the PBL process. Consequently the design and development of the Problems of the Week and the multimedia teaching modules embody the psychological and educational rationale of PBL. This is important as Kennedy and McNaught (1997) suggest that “a culturally inclusive approach should be used in IMM design. . . it is essential to consider both the design and use of IMM within particular educational contexts” (p. 4). What is of importance is to “match the desired educational outcomes of an interactive multimedia module with the elements which have the greatest potential to achieve those outcomes” (Kennedy & McNaught, 1997, p. 7).

Another major issue in relation to the medical curriculum is the emphasis on Directed Self-Learning (DSL) as opposed to Self-Directed Learning (SDL). This concept of DSL fosters a more individualised approach to learning. Students will need to develop skills in personal time-management. They will need to determine what resources are most relevant for their needs and allocate time appropriately.

5. FUTURE DIRECTIONS

In March 1999 the new medical curriculum will be launched and will include a substantial component of PBL. It is expected by this date that 18 problems of the week and the relevant multimedia teaching modules will be integrated into the TopClass Learning Framework for utilisation by the medical students. As a means of introducing both the students and staff to the learning framework a DSL module will be developed dealing with some basic principles of Medical Informatics. This multimedia teaching module will provide an orientation to the learning framework and the application of computers in the practice and management of medicine.

Other future initiatives will focus on the relevance and effectiveness of PBL for medical teaching. Research on the educational effectiveness of the IT component of the new curriculum will focus on the Problems of the Week and the DSL teaching modules. This research will examine the effects of PBL and computer based learning on the teaching of medical concepts to students. Information obtained from this research in 1999 will be utilised in future design and development.

It is also expected that as students graduate from the program that there will be a greater call for continuing education. It is planned to expand the intranet learning environment into an internet based system for life-long learning.

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