Review

The Use of Problem – Based Learning in Medical Education

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Since the introduction of a problem – based learning (PBL) curriculum at the McMaster University School of Medicine in 1969, many medical schools in different regions of the world have adopted this approach, usually with some variations to suit their local needs. The aims of this review are to report some of our experiences at McMaster, to discuss some of the concerns which are associated with the introduction of PBL in a traditional medical school, and to review our recent experience in the introduction of PBL in Physiology in a traditional medical school. Some of the advantages of PBL are: early exposure of students to clinical settings and patients; motivation to learn is self – imposed, because students can see the practical application of the knowledge they are acquiring during their studies; and the acquisition of various learning skills, which will assist them to become lifelong learners. There are also some perceived weaknesses to PBL, which include a lack of traditional structure and progression, and a lack of depth in the knowledge acquired. Teachers with these concerns do not recognize the integrative nature, and you – learn – what – you – need aspect of PBL. Specific evaluative tools have now been developed, which will provide better measures of the learning behaviour, knowledge and clinical skills. Our recent experience in the introduction of PBL in the teaching of Physiology at the University of Hong Kong shows that with appropriate training of the students and teachers, high school students entering first year university are capable of benefiting from the PBL approach. In conclusion, any modification or improvement in the curriculum needs to be based on sound reasoning and upon experimental evidence. We have gained a significant amount of knowledge about the use of PBL in medical education since 1969, but further improvements and refinements are still necessary in order to meet the needs of the students, and that of the society.

Key words: problem based learning, medical education, tutorial learning

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"You can only learn what you don't know"
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INTRODUCTION

The use of real – life problems and inten-

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sive group discussion leading to tentative solutions had been a feature of the Harvard School of Business for decades [1]. However, the utilization of a problem-based learning (PBL) approach in medical education has been very slow in coming. At present, most medical schools around the world still use the traditional didactic teaching method. This is in spite of the warning about the pedagogical errors and information overload that get in the way of learning and dissatisfy students [2]. As quoted by Kassebaum [2], William Osler had reminded medical educators that education is a lifelong process, and that 'we can only instill principles, put the student in the right path, give him methods, teach him how to study, and early to discern between essentials and non-essentials.' The use of an integrated approach in medical education in the first two years of the curriculum was introduced by Case Western Reserve University School of Medicine in the U.S. in the 1950s, but 'it was the innovation of the problem-based approach at McMaster University in the late 1960s that blazed the trail of student-centered, interdisciplinary teaching and learning permeating the entire medical school curriculum.' [2] Subsequently, variations of the McMaster model have been adopted by a number of schools in the U.S., including New Mexico, Michigan State, Bowman Gray, Rush, Tufts, Harvard and Southern Illinois [2]. Some of the educators from McMaster University have played a facilitative role in the early planning process of new curricula in some of these universities such as the University of Hawaii [3] and Harvard. Presently, countries besides Canada and the U.S. with universities which are using, or are in the process of introducing PBL in their medical education include Australia, Bahrain, Brazil, Chile, Egypt, Great Britain, Hong Kong, Indonesia, Malaysia, the Netherlands, Nigeria, the Phillippines, Sweden, Switzerland, and Taiwan.

With the explosive growth of information in medicine and health care areas, it is not possible to teach students during their studies at the university all the information and techniques they will need in the practice of medicine. The need for reform in medical education, is summarized in a report prepared by the Association of American Medical Colleges' Panel on the General Professional Education of the Physicians and College Preparation for Medicine, the so-called GPEP Report published in 1984, with the title 'Physicians for the Twenty-First Century' [4]. Their conclusion on acquiring learning skills stated: 'To keep abreast of new scientific information and new technology, physicians continually need to acquire new knowledge and learn new skills. Therefore a general professional education should prepare medical students to learn throughout their professional lives rather than simply to master current information and techniques. Active, independent, self-directed learning requires among other qualities the ability to identify, formulate, and solve problems; to grasp and use basic concepts and principles; and to gather and assess data rigorously and critically.' [4]

The aims of this paper are to review some of our experiences at McMaster, to discuss some of the concerns which are associated with the introduction of PBL in a traditional medical school, and to review our recent experience in the introduction of PBL in Physiology in a traditional medical school.

McMASTER PHILOSOPHY IN MEDICAL EDUCATION

A Brief History and Characteristics

Planning for the new medical school and curriculum at McMaster University was initi-

ated in 1966, with the first class enrolled in 1969. The approach taken by the planning group, as recalled by the Dean of that time, John Evans, was to stay away from the standard building – block structure, where a lot of content is shoved down the throats of the students, which they do not retain anyway, and adopt a system where students are actively involved in the learning process [1]. The end result was the birth of the three – year program, characterized by the absence of discipline – oriented subjects, the emphasis on problem – solving, and an integrated approach to human biology [1]. The key features of the program are: the analysis of health care problems as the main method of acquiring and applying knowledge; the development of independent, lifelong learning skills by students; and the use of small tutorial groups, with five or six students and a faculty tutor in each group, as the central educational event [5,6]. The curriculum structure consists of a series of interdisciplinary blocks (or Units), including the final year of clinical clerkship rotations. Clinical skills, including communication skills, are learned through an integrated parallel arrangement from the beginning of the program. There are no discipline – specific courses [5]. A major revision of the curriculum took place in 1983, in order to: incorporate new knowledge on human biology, health care, and the determinants of health; define the program objectives more clearly, so that the evaluation system can be improved; and to allow students more flexibility in the duration and scope of their studies, with special opportunities and encouragement for the individual student to organize an 'enrichment year' to prepare for a special career in the health field [5]. Improvement and changes in individual Units and in the program are on – going, coupled with the regular change – over of educational leaders. The Chair of the program and chairs of various Units have a term of three years, renewable once. This allows a steady infusion of energy, ideas and interest in the planning of the program and that of the Units. Other unique features of the program include the exposure of the students to clinical settings and patients from the very first week in the program, a lack of traditional examinations and assignment of grades at the end of each Unit, and the involvement of students in the decision – making process of the program, such as the selection of educational leaders, and participation in various educational committees.

THE PRODUCT OF McMASTER MEDICAL SCHOOL

Motivation to Learn and Achievements

When the question was raised in 1989: 'Has the McMaster experiment delivered a better product than would have resulted from a conventional curriculum?', it was stated that the answer is obscured, because it is difficult to differentiate between the effects of curriculum, pedagogy, and the quality of the students [2]. However, based on the survey of the graduates and their clinical supervisors, the findings are that most of the graduates

1. enjoyed their medical education;
2. consider themselves well prepared for the next stage of their post – graduate education;
3. are sought after by residency program directors;
4. perform at a satisfactory level on licensing and certification examinations;
5. are judged by postgraduate clinical supervisors in various Canadian centres to demonstrate most of the performance objectives of the M.D. program at a higher level than comparison groups of peers from other institu-

tions;

6. have a somewhat different pattern of career choices, in comparison with matched groups of Canadian medical graduates; this pattern includes a higher proportion involved in education and proportionately more who have chosen careers in academic medicine; and

7. demonstrate some interesting differences in practice behaviour [5].

Needless to say, student satisfaction plays a major factor in the type of education they have been given at McMaster, because they can see the practical application of the knowledge they are acquiring during their studies.

One controversial issue concerning McMaster graduates, has been their somewhat lower pass rate on their first attempt to pass the national licensing examination [1,5]. One of the contributing factors was thought to include the lack of familiarity of McMaster graduates with the multiple-choice question format used in the licensing examination [1], and it has been argued that the achievement on examinations using multiple-choice questions, or the rub-out patient management problem format, bears little relationship to measures of actual clinical performance [5]. Nevertheless, the performance of McMaster graduates in the national licensing examination has improved in recent years, with average passing rate at first attempt at or above the national level of 95% during the past 4 years. In some years (1993, 1996), the pass rate was higher than the national average (96 and 99% respectively). The reason for this improvement is unknown. There may be two contributing factors. One is the specific feedback given to the students after they have taken the practice examinations given by the University of Toronto. The other is the introduction of Personal Progress Index (PPI) test in the program in 1992. PPI uses a multiple-choice question format to assist the students to gauge their progress in their knowledge base during the course of their studies at McMaster [7]. Studies to date indicate that PPI is a reliable indicator of the growth of student performance across the three years of the program [7]. PPI has a small effect on student learning but virtually no effect on tutorial function. A consistent relationship between PPI performances and performances on the national licensing examination has been found, and this relationship appears to be established at least a year prior to graduation [7]. It is interesting to note that at the National Taiwan University College of Medicine, which introduced small group tutorials and PBL in 1992 in their 3rd and 4th year classes, the performance of the students at the National License Examination is at least as good as before [8].

CHARACTERISTICS OF STUDENTS FOR PBL

Elements of Concerns

Maturity

Students entering the McMaster Medical Program usually have an undergraduate degree, and some (ranging from 8-33%) also have graduate degrees (i.e. Master or Ph.D.). This is in contrast with some schools where high school graduates are admitted directly into medical program. Some educators are concerned that high school graduates may lack the level of maturity for them to succeed in a PBL program. Our recent experience in introducing PBL format in the teaching of Physiology in a traditional medical school has shown that with some training, high school students entering first year university are capable of benefiting from the PBL approach (see below).

Another unique feature of McMaster student composition, is since 1971, McMaster has

accepted an increasing proportion of women (from 10% in 1971/72 to 50% in 77/78) [1]. In recent years, the proportion of women has always been higher than men, and in one year, it has reached 73% Nationally, McMaster usually has the highest proportion of women in the program compared with other medical school (e.g. 1994/95) [9].

Science background

From the beginning, planners of the McMaster program had decided to take a different approach in admission, in order to attract students with diverse backgrounds [1]. Students without science background have been admitted to our program even to the present day. A study of the performance of students with and without the usual prerequisites to attend medical school in North America was carried out across four classes (1976 – 80). No difference in performances was found in the first postgraduate year [5]. These results are similar to earlier studies when a similar comparison was made of the initial six medical classes at McMaster [1]. No difference was detected between the two groups of students on their perceptions of the medical curriculum, or on their evaluation of their preparedness for the first year of postgraduate training. There was also no difference in their choice of speciality, location and type of practice. Their clinical supervisors also could not detect the difference between those with or without a science background [1]. It therefore appears that students with nonscience background are able to adapt quickly and catch up with their classmates during the three – year program.

Cultural background

Teachers in Asia often wonder whether students in their region can benefit from the PBL approach, because they perceive that students from Asia are often very passive when they relate to their teachers, in contrast with students in North America and Europe, who are generally more out – spoken. There is however no evidence to support this concern (see below).

TUTORIAL LEARNING

Teacher – or Student – Centered?

In a traditional tutorial format, teachers play a central role as the persons who possess the knowledge, and therefore are in the position of authority, and will provide the ultimate answers to most questions. This is different from a problem – based, small group, tutorial learning, where the role of the tutor is to facilitate the learning process of the students. It is not essential for the tutors to be a content expert to be an effective tutor. In a typical PBL tutorial, students are presented with clinical information on a patient. Students go through the process of problem identification, hypothesis generation, the generation of learning issues, and setting of group and personal learning objectives. It is not important for the students to come up with the correct diagnosis or treatment, but to use the clinical problem as a focus to acquire the knowledge in order to meet the learning objectives specific to each Unit. Tutorial learning is supplemented by large and small group sessions, which are similar to the traditional lectures, but these are usually integrative sessions rather than discipline – based. Students can also contact resource persons from various disciplines for information on resource materials. Tutorial learning remains the central focus of the learning process.

There are several advantages in PBL [10]. In PBL, motivation to learn is self – imposed. Students are building new knowledge on existing knowledge, so that there is depth in the cover-

ing of the materials. The integration and application of the knowledge (problem – solving) go on in parallel, so that the students see the usefulness of the information they have acquired. There is generally a wider coverage of the topic (big picture). Students also develop other skills in the process, such as inquiry skill, critical appraisal skill, communication skill, and group skill. Finally, students in a PBL program should become lifelong learners, who realize that acquisition of new knowledge is an ongoing process.

There are some perceived weaknesses to PBL [10]. Lack of traditional structure and progression is a concern for those teachers who are used to the subject and discipline oriented approach. There is a feeling that students in PBL lack depth in the knowledge they have acquired, and that too much time is spent in a tutorial talking. However, as pointed out by Woods [10], we must learn to limit the tendency of **wanting** to know everything from one problem. Instead, we can begin to move modestly by using what we **need** to know for this particular problem. One barrier which is sometimes difficult to overcome in the change from a traditional to PBL curriculum, is the integration of preclinical teaching materials with those of clinical teaching. Teachers in these two areas often work in isolation.

Confusion can arise for some teachers who equate PBL with problem solving ability. PBL is a process of learning using a problem as a starting point, whereas problem solving ability is the application of the knowledge acquired to solve a problem. Nevertheless, these words are often used interchangeably, or it is assumed that PBL is a means to the end of acquiring problem – solving skills (PSS) [11]. However, as presented by Norman [11], the acquisition of PSS is not the same as the acquisition of knowledge, because studies have shown that the expert is distinguished not by any general skills, but by the possession of appropriate knowledge to resolve the problem. Norman also pointed out two advantages of PBL. The first is motivational – students clearly prefer this approach. The second is that PBL is deeply rooted in psychological theory. It is now well established that knowledge is much better recalled and applied in the context in which it was originally learned.

EVALUATION

Validity and Reliability of Assessments

In a tutorial based PBL format, in order to generate a cooperative and supportive environment for the learners, it is essential to avoid a competitive assignment of grades at the end of each Unit. Therefore tutorial evaluation tends to focus on the learning process, personal characteristics and group dynamics, and less on the evaluation of the knowledge the students have acquired. It is therefore not surprising that a recent unpublished study at McMaster University by J. Blake, G. Norman and C.B. Mueller (1994) has found that tutorial evaluation is not a sensitive measure of the acquisition of knowledge, when measured against the performance of the students in the PPI and in the national licensing examination (personal communication). Assessment of knowledge and clinical skills is more reliably done with the PPI, Clinical Reasoning Exercises (CRE), and Objective Structured Clinical Examinations (OSCE).

In a traditional system, regular examinations may give students a false sense of security, because performance above a certain level (e.g. 80% score in an examination) tends to put them in the excellent category. The question is what about the areas (i.e. the remaining 20%)

the students did not know the correct answer? Hence the quotation from Dr. Mueller that 'you can only learn what you don't know' at the beginning of this review. The PBL approach has the virtue that in a non-competitive tutorial setting, students quickly learn to identify and freely admit their area of deficiency, sometime with the help of their tutorial members, and plan their learning strategies to acquire the knowledge they need. It is therefore not surprising that students in a PBL program usually have a high degree of anxiety about whether they have learned enough.

PBL IN THE TEACHING OF PHYSIOLOGY

A Hong Kong Experience

During a period from 1992 when one of us (C.Y. Kwan) has served in the Faculty of Medicine of the University of Hong Kong as Professor and Chair of Physiology, Committee for Selection of Senior Teachers had asked Kwan whether he would consider changing the medical curriculum into a McMaster format. Kwan responded that replacing the traditional medical education system in Hong Kong with the McMaster system simply for the sake of change for innovation, would be unrealistic and probably detrimental because of the vast differences in the administrative structure, and the sense of value in learning and teaching in teachers and students between these two medical school systems. However, he believed that the philosophy of PBL ought to be introduced in some form which will be compatible to and appropriate for the local environment to enhance cooperative and integrative learning.

PBL was first introduced to the Department of Physiology at the University of Hong Kong in the academic year 1992/93 following a department retreat, in which the call for reform in teaching and learning of Physiology was collectively recognized. It was, however, difficult at the beginning because teachers' understanding and experience of PBL varied or remained vague. Students in Hong Kong also resisted PBL because it was not the way they were used to learn throughout their primary and secondary school experience, as have been observed by Biggs and Watkins [12]. It was pointed out that a systematically and properly planned introduction of PBL to preclinical teachers and medical students is a major first step for a curriculum reform [13]. In 1994/95, with the support of an Action Learning Project (ALP) Grant, R.M.K.W. Lee from the Department of Anaesthesia of the McMaster University was invited as a teaching consultant, to go to the Departments of Physiology and Pathology to introduce the PBL approach in medical education. Workshops on PBL and small group tutorials were organized and accompanied by a number of consultation group discussions and meetings with medical students as well as teachers. The overall progress has been presented and included in an interim report of ALP [14]. The major observations and assessment by the teaching consultant revealed that when given appropriate guidance and encouragement, the first year medical students at the University of Hong Kong can perform very well using a PBL approach in a small group tutorial setting. Most of the students were able to arrange their materials in a logical sequence, and to provide a well-organized, clear presentation of their materials, demonstrating both breadth and depth, and integration of the materials. The students appeared to be comfortable in integrating clinical findings with basic physiological concepts, and came up with reasonable diagnosis and management strategy. In May of 1997, Lee as invited by the Faculty of Medicine, Uni-

versity of Hong Kong to conduct tutor training workshops, with student volunteers from the second year providing the tutorial group experience for the teachers. Lee observed again that these students exhibited the levels of maturity and sophistication in their learning which are comparable to students in North America, and after their experience in two tutorials, some of them prefer PBL, and a majority of them prefer a combination of PBL with lectures.

In 1993/94, a position paper on undergraduate medical education, entitled Tomorrow Doctors was issued by the British General Medical Council. It was recommended that the burden of factual information imposed on students in undergraduate medical curricula should be substantially reduced, and that the core curriculum should be system – based and integrated, thus eliminating the rigid pre – clinical/clinical division and the exclusive departmentally based courses. In 1994/95, the University Grants Committee of Hong Kong introduced the Teaching & Learning Quality Process Audits in Hong Kong, in order to improve the quality of teaching at tertiary institutes. An analysis based on the report for the Careers Advisory Board Working Group on Core Competencies for Undergraduates of the University of Hong Kong [15] revealed that Hong Kong University students were generally deficient in lateral thinking and communication skills. One of the recommendations by this Working Group was that introducing PBL to students will encourage them to take best advantage of the opportunities offered to them, and help them to overcome their initial resistance to a new and more challenging learning style. During this period, the new Dean of the Faculty of Medicine, S.P. Chow, has announced his intention to put the undergraduate medical curriculum under reform. Coordinators of the ALP team (1994/95) have participated in the design of the new curriculum which will be implemented in the fall of 1997.

CONCLUSION

Since the introduction of a PBL curriculum at McMaster University School of Medicine in 1969, many medical schools around the world have adopted this system of teaching, generally with some modifications to suit their local needs. As learning is a continuous process, we need to examine our teaching methods regularly to see if they continue to meet the needs of our students. Any modification or improvement in the curriculum needs to be based on sound reasoning and experimental evidence. As we learn in scientific research, conclusions derived from logical reasoning are not the truth. It is only after experimentation and statistical analyses that we can be confident of where the truth lies. Experimentation in education needs to follow the same principle. In the tutorial PBL format, our colleagues at McMaster have been analysing the validity and sensitivity of various evaluation methods. We have gained more understanding about the evaluative tools we have been using. Even though enough progress has been made in this area, further improvements and refinements are still necessary.

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