CURRENT TOPIC

Adult learning theory, problem based learning, and paediatrics

T J David, Leena Patel

'A medical student faints at the sight of blood. Would you expect his pulse to be fast or slow? What underlying mechanism caused his fainting?'

This is the kind of problem that first year medical students in a problem based learning curriculum are asked to investigate, while their counterparts in traditional medical curricula are trying to memorise the names of all the holes in the skull.

In conventional medical education, the undergraduate student is given specific learning objectives in a particular discipline (for example biochemistry). Teaching (lectures, tutorials, practicals) is provided, and the students cram as much as possible in order to pass the examination. If successful, the cerebral hard disc is wiped clean, and the student starts afresh with a new discipline. Throughout, the process is in the control of the teacher.

Readers of this journal will recognise the conventional model, and may well think that the excellent outcome in their own case means that an ancient, well tried, and tested system should not be tinkered with. A somewhat anarchic alternative, problem based learning, which may disturb the equilibrium of those who are happy with conventional medical education, is explained below.

In problem based learning, the learner (undergraduate or postgraduate) decides on his or her own learning objectives as a result of exposure to trigger material (for example a written problem, a video, or a patient). The role of the teacher is to design trigger material that will interest the learner and cause the learner to generate appropriate learning objectives, and to provide the appropriate learning resources (for example library materials, computerised literature searching, video materials, skills laboratories, clinical exposure). Other than the design and provision of the trigger material, the whole educational process is in the control of the learner.

Adults and children learn in different ways

Paediatricians are champions of the concept that children are not just small adults. However, the converse is also true. Adults are not just large children. Any discussion about medical education, or an appreciation of how

damaging is the conventional system, is difficult without an understanding of how adults learn. Firstly, the word adult has different definitions. Biologically it is the age at which we can reproduce. Legally it is the age at which we can vote, obtain a driving licence, get married without consent, and so on. Socially, we become adult when we start performing adult roles such as full time worker, spouse, parent, and so on. In the context of this article, we are referring to the *psychological definition* of being responsible for our own lives, and of being self directing.

The way that children are taught is the only way of thinking about education that most of us know, for it has dominated school education, and even adult education, until recently. There are, however, differences in the child learning and adult learning models, and these are contrasted below. The jargon word for child learning is *pedagogic*, and for adult learning *andragogic*; we have avoided both terms in this article.

THE CONCEPT OF THE LEARNER

In the child learning model, the learner is a dependent person. The teacher has full responsibility for making all decisions about what should be learned, how and when it should be learned, and whether it has been learned. The learner submissively carries out the teacher's directions. In the adult learning model, developed and reviewed by Knowles,¹ the learner is *self directing*. Adults have a need to be perceived as being capable of taking responsibility for themselves; where adults feel that others are imposing their wills, there may be resentment and resistance. However, adults need help in making the transition from being dependent learners to self directed learners, for even though adult learners may be totally self directing in every other aspect of their lives, the minute they walk into a situation labelled 'education' (or any of its synonyms), they tend to hark back to their conditioning at school, assume a role of dependency, and demand to be taught.

THE ROLE OF THE LEARNER'S EXPERIENCE

In the child learning model of learning, learners enter with little experience that is of much value as a resource in learning. It is the

Department of Child Health, University of Manchester
T J David
L Patel

Correspondence to:
Professor T J David,
University Department of
Child Health, Booth Hall
Children's Hospital,
Charlestown Road, Blackley,
Manchester M9 7AA.

experience of the teacher, the textbook writer, and the audiovisual aids' producer that counts. The backbone is transmission technique – lectures, assigned reading, and audiovisual presentations. By contrast, adults enter into an educational activity with greater volume and different quality of experience from youth; adults are themselves a rich resource for one another. Another consequence of an adult's experience is that it becomes increasingly the source of an adult's self identity. If asked 'who are you?', your 8 year old son might give his name, address, name of school, and the occupation of his father; his self identity is derived almost entirely from external sources. However, adults derive their self identity from their experience. So, if in an educational situation an adult's experience is not valued, ignored, or not made use of, it is not just the experience that is being rejected; it is the person. Hence the importance of using the experience of adults as a resource for learning. There is also a negative consequence of adulthood. Because of their experience, adults often have developed habitual ways of thinking and acting, preconceptions about reality, prejudices, and defensiveness about former ways of thinking and doing. Adult learners need help to become more open minded.

READINESS TO LEARN

In the child learning model, learners mature from grade to grade, becoming ready to learn what they need in order to advance to the next grade level. Readiness is largely a function of age. In contrast, adults become ready to learn when they experience a need to know or do something. Adults do not need to wait for readiness to develop naturally. Things can be done to induce it, such as exposing learners to more effective role models, and to diagnostic experiences in which they can assess gaps between where they are and where they want to be.

ORIENTATION TO LEARNING

In the child learning model, learners are *subject orientated*. They see learning as a process of acquiring prescribed matter content. The curriculum is organised according to subjects. Because adults are motivated after they experience a need in their life, they enter with a *life centred, task centred, or problem centred* orientation to learning. For adult learners, learning experiences need to be orientated to life rather than to subject matter.

MOTIVATION TO LEARN

In the child learning model, learners are motivated primarily by *external* pressures from parents and teachers, competition for grades, and the consequences of failure. Although adults also respond to these *external* motivators and others such as a better job and salary increase, the adult model predicts that more potent motivators will be *internal*: self esteem, recognition, better quality of life, greater self confidence.

CHOOSING THE MODEL

Although for centuries we only had one model, as will be evident from the above, we now have two sets of assumptions about learners. Despite the phrases child learning and adult learning, these models are not entirely age dependent. In some situations, such as when learners of any age are entering a totally strange territory (for example, confronting a complex machine they have never seen before), they may be entirely dependent on didactic instruction before they can take much initiative. In many more instances, however, particularly with adults, the adult learning model would be more applicable, particularly if the learners have had some orientation to self directed learning. The adult learning model may apply to children more than we think. For example, children are very self directed in their learning outside school and could also be more self directed in school. Children bring some experience with them, and this experience could be used as a resource for some kinds of learning. Children are also more ready to learn when they experience a need to know than when they are told they have to learn.

Brief history of problem based learning in medicine

In 1965, the McMaster University in Ontario set up an innovative medical school which employed problem based learning rather than conventional medical education. Others have followed, most notably the University of Limburg at Maastricht, where a medical school modelled on McMaster was established in 1974. Much of the further research and development of problem based learning in medicine has taken place in Maastricht, with the result that McMaster is now incorporating a number of innovations from the Netherlands. The 'disease' has spread to other parts of North America, Australia (most notably at Newcastle, New South Wales), and the Third World. Europe has been slightly resistant to infection, some of the notable exceptions being Linköping in Sweden and Manchester. The latter is the first UK medical school to have totally converted the preclinical course into a fully problem based course, although there are signs that others are likely to implement problem based learning.

What happens in problem based learning?

The process follows identifiable steps. The students are provided with so-called stimulus or trigger material. An example might be the fainting medical student episode, or it might be a more detailed problem, a video or a patient with a problem. The nature of the stimulus material is critical; the trick is to produce material that is stimulating, contextual, and will lead the students to formulate most or all of the learning goals set by the course management group – this is discussed later. Students work cooperatively in a small group (eight to 10). They identify the problems, they use prior

The 'seven jump': the tutorial process

1. Clarify terms and concepts in the problem which are unknown to you.
2. Define the problem, that is list the phenomena to be explained.
3. Explain the problem; try to produce as many different explanations for the phenomena as you can think of. Use prior knowledge and common sense.
4. Arrange the explanations proposed; try to produce a coherent description of the processes that you think underlie the phenomena.
5. Formulate learning goals.
6. Attempt to fill the gaps in your knowledge through individual study.
7. Share your findings with your group and try to integrate the knowledge acquired into a comprehensive explanation for the phenomena. Check whether you know enough.

knowledge to try and explain them by brainstorming, and then they formulate learning goals. The students then attempt to fill gaps in knowledge through individual study and inquiry. The students share their findings and try to integrate the knowledge acquired into a comprehensive explanation for the phenomena or problem. In Maastricht, the process has been divided into seven discrete steps, known as the 'seven jump' (the term comes from a Dutch children's song); this is shown in the table.

The process is best illustrated with an example taken from our own experiments with problem based learning in paediatrics. Two 'firms' of four students are combined to form a group of eight; they work together throughout the eight week fourth year paediatric clerkship. The group meets twice a week, on a Monday and a Thursday. At each meeting the group elects a chairperson and a secretary; the latter is a scribe who records items on a flip chart.

An example of a problem would be as follows:

Rapidly fatal illness

John Smythe, aged 4 years, was noted to be unwell and feverish one morning, and his mother called the GP who arrived at 1110. He found that the axillary temperature was 38.6°C and when he examined John's chest he noted some purpuric spots on both arms. He telephoned the hospital, and agreed admission with the paediatric senior house officer. An ambulance was called, and John arrived in the accident and emergency department at 1155. By the time he had arrived his condition had deteriorated, and the purpuric rash was noted to have extended on to the trunk and legs. Benzylpenicillin 1 million units was given intravenously at 1205, but despite supportive treatment he then rapidly deteriorated and had a cardio-respiratory arrest from which he could not be revived at 1240.

Explain the skin lesions and rapid death in terms of the underlying process.

Having ensured that there were no terms that the group could not understand (step 1), they would then proceed to step 2 and briefly list the phenomena to be explained. A typical list would include fever, purpuric rash, rapid deterioration, and death. (This is an exceptionally short list; many problems would generate a

larger number of phenomena.) Step 3 is an attempt to produce as many explanations as possible for each of the phenomena. There is no need to weed out unlikely or doubtful explanations at this stage. In step 4, there is an attempt to produce a coherent description of the processes. This is relatively difficult for this particular problem; our students have a poor understanding of dermatological terms such as purpura, never mind the pathogenesis of purpura. Interestingly, not all groups appreciate that the child probably had meningococcal septicaemia. Steps 3 and 4 are the most difficult, and may take 20 to 30 minutes. Then follows step 5, in which the group makes a list of what it feels should be the learning goals – topics to be explored before the next tutorial. Step 6 comprises whatever happens between this and the next tutorial. It will include a variable mixture of textbook reading, literature searching, and the use of other learning resources, for example, video tapes, going to talk to a dermatologist or pathologist or haematologist or whoever the individual student thinks can help. Each student addresses every learning goal; the learning goals are *not* divided between different students. At the second tutorial, the students share their findings, indicating both what they have found and their source. The information they find is often conflicting, and an important aim is to critically appraise the evidence for or against a particular statement: 'the textbook says ..., but what is the evidence?'

There are a number of practical issues. The role of the tutor is difficult, especially for doctors who are most accustomed to providing information rather than helping students to think. Remaining silent when students say something wrong (which they frequently do) is especially difficult, but absolutely essential. If students appear to be going completely off the rails, for example during steps 4 or 7, then the tutor needs to try to provoke some lateral thinking. To do this without being directive can be hard. One of a number of approaches is to ask the proponent of a particular incorrect idea how he or she can reconcile this with other (conflicting) facts which have been presented. It is desirable that the role of chairperson and scribe should rotate among the group. The chairperson has the important role of controlling over eager or domineering contributors and encouraging the more reluctant members of the group; it is important that all members contribute – the only spectator should be the tutor.

Problem design

The challenge is to design a problem that is both interesting and will lead most students to the intended learning goals. The design of written problems is complex; the learning goals have to be appropriate for the level of knowledge of the students, and must fit in with the general aims and objectives of the course. A problem may need to be amended several times before it is satisfactory. In the above example the intended learning goals

were (i) the pathogenesis of meningococcal septicaemia, (ii) the mechanisms of shock, and (iii) toxins and inflammatory mediators. Pieces of information may inadvertently lead students off at a tangent. For example, providing the exact temperature in the problem described above often caused students to discuss how high this was, and whether or not the height of the fever was a contributory factor. (In the less focused McMaster approach, such diversions would be regarded positively.) Giving the dose of penicillin created a diversion for all groups of students, who embarked on a discussion as to what was or was not the correct dose of penicillin, and whether over or under dosage could have contributed to the outcome. The amended problem stated that the dose was appropriate for the weight and condition of the child. It is of course neither possible nor appropriate to eliminate all possible causes for diversion. Some students offer a possible explanation for the further deterioration as an anaphylactic reaction to penicillin, and clearly this is an appropriate topic to consider.

Practical difficulties

In our own pilot studies, attendance at tutorials has been voluntary. However, at the first tutorial, the process is briefly outlined to the students, and the need for regular attendance is self evident. The number of poor attenders has been negligible. A greater challenge are the silent minority; some are shy, fearful of 'getting it wrong' (common), or idle. One role for the tutor is to ensure that the chairperson is trying in a kindly way to involve these members of the group. By far the greatest challenge, however, is that our students are quite unaccustomed to controlling their learning in this way. They regularly look to the tutor for non-verbal clues as to whether or not they are on the right track; a deadpan response is important. Even though we explain the aims and objectives of problem based learning, students remain very concerned to know whether they 'got it right' or not. The greatest difficulties are the students' low capacity for self direction; many find it hard to find things out for themselves, and despite being in the fourth year of an undergraduate medical degree they often have poor ability to use the full resources of the library. Experience elsewhere is that students may take many months to become accustomed to self directed problem based learning. Many of the problems our students have experienced will disappear in two years' time, when students reaching the fourth year will have encountered Manchester's fully problem based first two years.

How does problem based learning work?

Problem based learning is an approach that is based on research into how adults learn most effectively. The comments below are extracted from more detailed discussions of the basis of problem based learning.²⁻⁴

ACTIVATION OF PRIOR KNOWLEDGE

Activation of prior knowledge facilitates the subsequent processing of new information. New knowledge has to 'adhere' to prior knowledge, and for integration to take place the prior knowledge has first to be retrieved. Studies have shown that recall of new information is poor when subjects fail to reactivate relevant knowledge. Small group discussion of a problem, as described above, does ensure that prior knowledge is activated, and used to try to explain the phenomena observed.

ELABORATION OF KNOWLEDGE

Elaboration of knowledge at the time of learning, as happens in problem based learning, enhances subsequent retrieval. Memory of subject matter and ability to use knowledge is enhanced when students have the opportunity to elaborate on the knowledge at the time of learning. Elaboration can take several forms such as discussion, answering questions, or using the knowledge to understand a problem.

CONTEXTUAL LEARNING

The difficulty in remembering the name of a colleague when encountered at the shops is an illustration of the influence of context. Another example may be the difficulty that some people have with passing examinations, where recall of information is in a different context to that in which it was acquired. The context means all the features of the environment at the time of learning, including items which are quite irrelevant. So, for example, when material about a particular patient is recalled, irrelevant features (for example, the child was in the end cubicle on ward 4 where the plaster has come off the wall) will be recalled in addition to clinically important features. Learning a discipline (for example, anatomy, biochemistry, or pharmacology) outside of a clinical context is an effective way to ensure that little information is recalled beyond the date of the examination. Problem based learning addresses this issue, because all relevant concepts are learned in the context of a human or clinical problem.

TRANSFER OF PRINCIPLES AND CONCEPTS

In conventional medical education, students in their preclinical years are taught basic principles or concepts of biomedical science, often with examples of their application, in the hope that these concepts will be available and used in the solution of patients' problems. This is referred to as *transfer*, the extent to which a concept or principle learned in one context can be transferred or applied to another problem that requires the same principles for resolution. Unfortunately, research has shown that transfer is unlikely to occur unless the context or surface similarity of two problems is matched very closely. Studies of problem solving have shown that any change in the surface features of a problem impede transfer, so that a problem solver does not recognise the similarity of the underlying concept.

Experiments contrasted a group (the 'memorise' group) who were asked to read and remember a problem and then had the solution explained, with another group (the 'problem solvers') who were engaged in solving a problem and who were then given the solution also. Then both groups were given sets of test problems that illustrated the same problem in very different contexts from those in which it had been presented originally. The results showed that those who were asked to solve the problem and received feedback about the problem transferred the concept to the new problem nearly 90% of the time; this compares with about 60% for those who were simply asked to memorise the problem. Other experiments showed that (a) simply engaging in problem solving, without feedback, gave no advantage over the memorise group; and (b) in the memorise group, the performance was about 60%, whether or not feedback had been given. Learning concepts while trying to solve a clinical problem in problem based learning is analogous to the problem solving conditions of the above experiments, while teaching a concept and then having students apply it to a problem is analogous to the memorise condition.

INTRINSIC INTEREST

A student's intrinsic interest in the subject matter, with a consequent impact on the motivation to learn, is enhanced by problem based learning.⁵ The power of interest is easily overlooked. One of us recalls the experience of putting down a gripping paperback thriller in favour of a remarkably entertaining and intrinsically interesting book about the very dullest of all subjects (bar Latin that is), statistics.⁶

LIFELONG LEARNING

The end point of conventional medical education is passing the final examinations and qualifying as a doctor. There is little focus on the capacity to cope with the changes in medical practice that will occur during the next 30 years of clinical practice. There is increasing appreciation that one aim of undergraduate education should be to equip future doctors for a lifetime of self motivated and self directed learning, a goal that is not achieved by passive learning in a succession of lectures. There is evidence that students in a problem based curriculum acquire more self learning skills than students in a conventional curriculum, and that the difference is sustained well beyond the duration of the curriculum.

Problem based learning is easily undermined

In a sense, problem based learning is not very robust. It is easy to undermine and devalue or short circuit the whole process.

It is critical that students formulate their own learning objectives. This process is short circuited if students are given specific learning objectives. In specific problems, it is essential

to avoid 'advance organisers', that is labels which focus the students. The 'rapidly fatal illness' problem described above would be of little use if labelled 'endotoxin and its harmful effects'. Tutor behaviour is important; for example, providing direct answers will short circuit the whole process. The topic of the tutor role, the problems of small groups, and the degree of subject matter expertise of the tutor are subjects in their own right, and are discussed elsewhere.⁷⁻⁹ Lectures devalue problem based learning and have no place, other than to explain particularly difficult topics which are not readily accessible in other ways.

The single biggest challenge is the appropriate design of pass-fail examinations*. In conventional medical education, students are highly exam driven.¹⁰ They study to pass 2nd MB, then 3rd MB, and then final MB, often subdivided into a whole series of individual pass-fail examinations in separate subjects. Their activities are very heavily influenced by the need to pass exams. Their attendance at, and interest in, various learning opportunities is governed by the relevance to examinations. Problem based learning is not compatible with conventional examination systems; students simply find out what they need to pass the exams, and concentrate on this objective. The simplest solution is to avoid all pass-fail examinations. This was until recent years the situation at McMaster, where the first such examination faced by students was the Canadian State Licensing Examination. (The reader can see why we used the word anarchic! The reader's instant response might be that this could not possibly work for one's own students – without examinations they would do no work at all. The answer is that in the present totally exam driven system, this is undoubtedly true, but it is a function of the system and not the students. If one wants to change student behaviour, then first of all the system must change.)

In order to avoid the steering effect of examinations, it is necessary to break the link between education and testing. To give just one of a number of possible examples (for other examples see Feletti *et al*¹¹) of how this can be done, educators at Maastricht achieved this by designing an examination, the 'progress test', that was so comprehensive as to be virtually impossible to study for, and by separating the assessment of progress through the curriculum from performance on any single examination. This has recently been taken up at McMaster, where it is known as the personal progress index.¹² The principle of the progress test is that it consists of a set of multiple choice questions (chosen because of cost effectiveness and high predictive validity) that is administered to all medical students in every year of the course four times a year. The questions are taken from the whole domain of medicine,

*Known in educational jargon as summative assessments, as distinct from formative assessments, examinations the sole purpose of which is to provide feedback to the student.

and *all students*, regardless of which year of study, take the same examination. The results are graded so that up to one half a standard deviation below the mean is taken to be *satisfactory* (S). Between 0.5 and 1.0 standard deviations below the mean is classed as *doubtful* (D). More than 1.0 standard deviations below the mean is classified as *unsatisfactory* (U). After each test, the student receives a test performance report describing performance in different domains, and a performance profile report in which performance is related to previous performance and to the performance of peers from the same year. The progress test system has a number of unusual advantages:

- Research has shown that it is impossible to study for the test. Thus the progress test eliminates activities solely aimed at passing exams.

- The test allows an individual student to follow progress throughout the course, and it has been demonstrated that students do indeed make steady progress throughout the course.

- Unlike the conventional system where a student studies a subject, is examined in it, and then forgets about it, the progress test encourages continuing interest in subjects previously studied, and research has shown, for example, improved knowledge in basic sciences occurring during the final years of the course.

- It makes it much easier to make structural changes to the curriculum. For example, one could switch a clinical attachment block into the preclinical years, which would be much harder to implement with an 'end of year' examination structure.

- There are no 're-sit' examinations, but simply further progress tests every three months.

- Students get detailed feedback after each test, so that they can see in which areas they are weak.

- The system minimises 'preparation anxiety', partly because the students become very familiar with the routine of taking the test, and partly because preparation is impossible, and known to be impossible.

A theoretical drawback to the progress test is regarded as being the fact that one could pass the exam without any knowledge at all of, for example, anatomy. Research has shown, however, that in practice this does not happen. In Maastricht, the students also receive pass-fail skills tests. In McMaster, there has been emphasis on subjective tutorial evaluation by tutors and peers. The test is of course primarily a test of knowledge and understanding, rather than one that, for example, calls for reasoned decision making in the face of an unfamiliar situation. Also, the progress test, like all multiple choice examinations, presents choices, whereas in real life doctors have to generate the choices themselves.

Evaluation of problem based learning

Local pilot studies have been evaluated only by

student feedback, which has been very positive. We are currently developing a randomised trial of problem based learning in paediatrics, because most of the studies thus far have been of problem based learning during the preclinical years. Thus, both at Maastricht and McMaster, problem based learning is mainly applied to the preclinical years (four years at Maastricht and two years at McMaster), the clinical part of the curriculum (two years at Maastricht and one year at McMaster) being conventional clinical clerkships. There are some reports from elsewhere about introducing problem based learning into the clinical part of the curriculum.¹³

The literature on the outcome of problem based learning has been reviewed in detail elsewhere.^{14 15} Sceptics can take comfort in the fact that there is no objective evidence that, for example, medical graduates from a problem based course are better doctors (whatever that term might mean) than those who experienced a conventional education. Enthusiasts will point to studies demonstrating better long term retention of knowledge, better study behaviours, greater student satisfaction, better performance of graduates, better lifelong learning, greater enthusiasm of teachers, and other positive outcomes in schools that have studied the effects of problem based learning.

Conclusions

Medical education has a responsibility to ensure that students are helped to develop generally applicable competences such as life-long education, critical reasoning, dealing with unfamiliar situations, collaborating in terms, and various levels of communication, from obtaining information to counselling, adaptation to change, and participation in change. None of these are well served by a conventional passive learning environment.

Reading about French cooking is a poor substitute for the real thing, and may be difficult to understand for someone accustomed to the plain English fare of bacon and eggs or fish and chips. Thus it is difficult to fully convey our enthusiasm for problem based learning in this short review. For the interested reader, we would strongly recommend a visit to the University of Limburg at Maastricht or the McMaster University at Hamilton, Ontario, both of which run short (one to three week) workshops on various aspects of problem based learning as applied to medicine. In addition, the University of Limburg runs a distance learning Master's Programme in Health Professions Education, in which one of us (LP) is currently participating. For further information, write to us, or direct to: Office for International Relations, Faculty of Medicine, University of Limburg, POB 616, 6200 MD Maastricht, Netherlands or Programme for Faculty Development, Faculty of Health Sciences – Room 3N51g, McMaster University, 1200 Main Street West, Hamilton, Ontario, Canada L8N 3Z5.

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