

The application of problem-based learning to the teaching of microbiology for pharmacy students

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Abstract

Problem-based learning (PBL) is an educational format, where students work in groups on a 'real world' problem with a tutor facilitating. A PBL task was investigated as a means of teaching a unit of microbiology to pharmacy students, providing an alternative to the more traditional lectures and practical work. The task, and its assessment, involved preparation of an abstract and a paper for presentation on the methods used to detect and identify food-borne pathogens.

The PBL project was favourably received by staff and students. Most students reported an increase in motivation to learn and interest in the subject, and the quality of the work was very high.

Challenges to the implementation of PBL include time issues, group-related issues, variability among facilitators, student evaluation and faculty acceptance and training.

Whilst more traditional teaching practices will continue to dominate, PBL certainly deserves a place in the teaching repertoire.

Keywords: *Microbiology, pharmacy, problem-based learning (PBL), real world*

Introduction—what is problem-based learning (PBL) and why choose it?

PBL is an important approach to education that involves challenging students with problems from practice which provide a stimulus for learning. PBL has been variously described. As Duch (1996) defined PBL as "learning to learn". Whilst Barrows (1986) defined PBL as "a learning method based on the principle of using problems as a starting point for the acquisition and integration of new knowledge." Although PBL encompasses a wide variety of educational methods, it is, essentially, an educational format, where students work in small groups on a "real world" problem. The process is student-centred and social. Participation assists not only the individual student's learning, but also, ideally, the learning of others in the group. The tutor acts as facilitator rather than lecturer, so PBL allows students to take responsibility for their own learning by making a topic their own, integrating existing and newly-acquired

knowledge and resolving a problem. PBL, therefore, fosters independent learning, critical thinking, a deeper understanding of material rather than a mere superficial coverage and, finally, the promotion of life-long learning. In addition the process serves as an aid to the development of key work-place skills, such as teamwork, communication, organization, time management and the ability to retrieve and synthesize information.

In many respects, the actual *process* is more important than the learning. Duch (1996) affirmed that PBL provides convincing evidence that active group learning and connections to 'real-world' applications, help students learn. Breivik (1992) acknowledged that to be effective and competitive, students needed more than a knowledge base: They also needed information literacy to enable them in the future to search out and integrate information.

Pharmacy teaching has traditionally been concerned with giving students a knowledge base, but

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the practice of pharmacy is mostly concerned with applying that knowledge. The focus has been on the *teaching* rather than the *doing*. The traditional curriculum is content-driven and does not always foster active learning, nor promote thinking and understanding. Hence, students achieve lower order cognitive skills such as basic recall and a shallow understanding. Knowledge acquired is neither retained nor applied. For this reason, there needs to be a curriculum shift to help students think laterally and critically. The work of a pharmacist is often concerned with solving problems related to a patient's health, frequently as part of a health care team. Pharmacy students, therefore, need to know how to access and process information, and be able to communicate this information effectively to peers, colleagues and patients.

As pharmacy students require a working knowledge of microbiology in the practice of their profession, it was decided to explore the PBL approach with a view to incorporating it in the teaching repertoire.

Impact of PBL on Health Sciences

Most of the literature reviewed for this project centres around the use of PBL in the Health Sciences, particularly for clinical case studies. Many papers on PBL raise questions about the effectiveness of traditional lecture methods in meeting the objectives of an education, particularly in the Health Sciences, where case studies are important for successful professional practice. However, there is a need to refine evaluation methods and encourage acceptance by faculty members.

Perhaps the earliest reported application of PBL in Pharmacy was the patient-oriented problem-solving instruction (POPS) module developed by Love and Shumway (1983) to teach pharmacy students problem-solving skills. A review of the status of PBL in pharmacy education by Cisneros, Salisbury-Glennon, Anderson-Harper (2002) unearthed a substantial number of articles on the implementation of PBL into a pharmacy curriculum. Recently, the American College of Clinical Pharmacy (ACCP) White Paper, as cited in Cisneros et al. (2002), drew attention to the discrepancy between pharmacy education and the actual practice of Pharmacy. The report called for pharmacy students to be more self-directed in their learning, and to be given problem-solving exercises involving critical thinking and ethical considerations, to prepare them for their future role as health care providers. PBL is one means of achieving this goal. However, although PBL had been used in Pharmacology and Medicinal Chemistry (Herrier, Jackson, Consroe, 1997) as well as Pharmacokinetics and Pharmaceutics (Sims, 1994a,b), all core areas in pharmacy education, the author could find no mention of its use for the teaching of Microbiology

to pharmacy students. Literature dealing specifically with the application of PBL to microbiology teaching is not plentiful, although Elizabeth Hoffman (2001) reported a successful transition from the traditional lecture format to a more active learning format for the teaching of Microbiology to both medical and nursing students.

Most authors report the many advantages and benefits of PBL. Ferrier (1990), when addressing the impact of PBL, states that, as yet, its effects on the professionalism of a health sciences graduate are unclear. However, in theory, such practitioners should possess a more self-directed approach in terms of furthering their own learning in their chosen field and this, in turn, should lead to a "better" practitioner. Whilst learning is the chief aim of PBL as distinct from finding a satisfactory solution to a problem, it must be stressed that in clinical situations, where patient health is at stake, finding the "right" solution is essential. In this case practising problem-solving is a means of ensuring that students follow approaches that will lead them to a satisfactory conclusion.

In spite of the many favourable comments about PBL in the literature, many authors also mention limitations of PBL, and/or report little difference between a PBL-based curriculum and a more traditional-based curriculum. There are reports that reveal very little difference in the performance of PBL-educated students and non-PBL-educated students, for example the study by Lancaster et al., (1997). Vernon (1995) reported that most tutors felt that PBL and the more traditional curricula were equally efficient as learning tools. However, PBL rated higher in student interest and reasoning, satisfaction and preparation for clinical placements.

In a further study by Vernon and Hosokawa (1996) that explored faculty attitudes, participants in the PBL method thought it to be superior to the old curriculum, whereas non-participants judged both to be about equal. Whilst Norman and Schmidt (1992) reported several benefits of a PBL curriculum, they suggested that this approach did not improve "content-free" problem-solving. Pickrell (1995) drew attention to the "considerable time requirements" involved, a "reduced breadth of learning" and "significant ambiguity". Schmidt, Boon, Kokx, Moust, Van Der Arend (1993) addressed the subject of effective tutoring, stressing the importance of "tutoring skill and content knowledge". These sentiments were echoed by Eagle, Harasym, Mandin (1992) who claimed that good tutors do make a difference.

On the other hand, Silver and Wilkerson (1991) considered subject expertise to work against the development of self-directed learning because the knowledgeable tutor was less likely to facilitate and more likely to interfere. Thompson and Williams (1985) talk about barriers to acceptance of PBL in

medical schools, citing “institutional complacency” and the perceived lack of recognition of good teachers compared with good researchers. Abrahamson (1998) cited faculty members’ inertia regarding curriculum change as a barrier to the implementation of PBL. Baker (2000) called for a move “from efficient teaching to effective learning”.

In general tutors report that students from both traditional and PBL programs tend to perform more or less equally, but that PBL provides better preparation for clinicals.

Students report greater enjoyment. Not surprisingly more active learners rated PBL higher than passive learners. It should be noted, however, that evaluation methods for PBL need some refinement: Assessing PBL outcomes is challenging because of the lack of standardized elements that can be replicated, measured and compared (Baker, 2000).

Aim

Since many positive outcomes have been reported as a result of the application of PBL, this approach was investigated in an attempt to encourage more active, self-directed learning, to make the unit more digestible and to provide an alternative to the traditional curriculum.

The topic chosen for the PBL exercise was a unit of microbiology dealing with methods for identification of food-borne pathogens. Pharmacy students need only a working knowledge of these tests: In all likelihood they will never have to perform them during their careers as pharmacists and so a detailed knowledge of these procedures is unnecessary. Students need to see the “big picture”, i.e. how all these tests are related, the importance of getting a correct identification and so on. However, students are likely to perceive lectures and practical work on a barrage of biochemical tests for a range of organisms as far from stimulating and a waste of time. Therefore, they are unlikely to absorb the content however positively and creatively it is presented.

Procedure

As part of the microbiology practical component in our pharmacy course, students study the various groups of bacteria and conduct simple, traditional biochemical and microscopic identification tests on a representative sample of these micro-organisms. The study of food-borne pathogens is relevant because gastro-intestinal upsets are common conditions encountered in pharmacy practice. A formidable array of rapid method techniques allows these pathogens to be easily identified. Time and economic constraints prohibit such tests from forming part of the practical component of microbiology for pharmacy students, who need only a working knowledge of

these tests. Therefore, rather than making the students carry out numerous testing procedures, a ‘symposium’ on the available methods, entitled, “Methods used to Detect and Identify Food-borne Pathogens” was planned.

Working in groups of 3–4, students undertook an investigation into the current rapid methods available for identification, comparing such methods with more traditional (and longer) methods. In this way, a wide range of organisms could be investigated, students would be given a general overview of the latest identification procedures and they would learn about the various tests from one another using a novel approach. Students were asked to select their groups and the bacterium they wished to investigate after the series of lectures on the systematic study of micro-organisms had been completed. The students previously had a general library tutorial at the beginning of the semester to help them research information. In addition, to avoid many student requests to manufacturers for information, the manufacturers were approached by the tutor for any relevant information (brochures, promotional material and the like) on their products. This information was filed in the form of a package that could be borrowed by students for their perusal.

As part of the facilitating process, students were given a tutorial to help them access additional literature specific to their topic (journals and the like), and to help them evaluate critically other information they may find, particularly by means of the internet. This tutorial also focused on information and guidelines for the preparation of an ‘abstract’ that outlined their ‘paper’ to be presented at the symposium. They were also given guidelines for presenting their information, as well as the criteria for the assessment.

Assessment

According to many authors, (e.g. Ramsden, 1988) the nature of assessment tasks influences the approaches to learning that students adopt. Students are more likely to practise solving problems if they perceive problem-solving to be emphasized and rewarded. For this reason, the PBL exercise constituted 15% of the final mark in this subject. Boud (2000) stated that assessment in higher education should not only meet the needs of the course, but also prepare learners for assessing themselves. Therefore students were encouraged to self-evaluate, in terms of their personal contribution to the project as well as the extent, to which the project met their educational needs.

Assessment revolved around the preparation of an abstract, the written paper itself and the presentation. Criterion-referenced marking was used for all aspects of the assessment. A combination of assessment methods was applied: Assessment by tutor, peers and

self. Aspects of students' work attracted either a group or an individual mark. The abstract was tutor-assessed and attracted a group mark. Each group was assessed on the quality of the presentation by the other groups of students (2.5%) and the tutor (2.5%). Each student submitted a written report that was given an individual mark (5%) by the tutor.

Results

The impact and the success or otherwise of the PBL exercise needed to be evaluated to determine its current and future value as part of the microbiology curriculum for pharmacy students. Student evaluation was done by means of a post-topic survey that also included an individual self-assessment exercise, as stated previously. Academic staff members' opinions were canvassed. The PBL project was favourably received by all concern. The reflections of the people concerned with this project are summarized below.

The tutor

Preparation required was varied and considerable. The timing of the task and its administration had to be carefully planned around other subject requirements. Provision, in the form of practical class time, had to be made for students to liaise with each other. The tutor met once with each group as a matter of routine, to ensure that each group understood the nature of the topic and to monitor the group dynamics, and at other times, on request, for guidance. The tutor had many roles once the task was underway. These included:

- encouraging the application of prior knowledge;
- providing constructive criticism;
- facilitating the group process;
- assessing the adequacy of information sources;
- initiating evaluation;
- helping the learning synthesis.

Time also had to be set aside to book a suitable, appropriately-equipped venue for the presentations, prepare the hand-out outlining the symposium topic and organism selection process, prepare the abstract guidelines, decide on suitable criteria for assessment and the assessment method(s) to be used, carry out the assessment and liaise with the manufacturers of rapid testing methods kits. In addition, students required a tutorial, as outlined previously. The busiest time occurred after abstracts were submitted. It was important to mark and return the abstracts promptly because this was closely followed by the presentations and submission of the final report. Now that the PBL task has been set up and instigated, administration in future years will undoubtedly prove to be much easier.

One potential problem associated with the exercise as it was administered is that learning outcomes

amongst individuals may lack consistency. Although each individual in each group gained detailed knowledge of their selected organism and its identification methods, doubts exist concerning the breadth of their knowledge of these methods. This sentiment has been echoed in the literature (Pickrell, 1995). However, in this instance, a detailed knowledge of these methods was not one of the identified aims, the *process* was all-important.

The student

Students were given a generous time frame and a total of six hours of their practical work time, in three discrete units of two hours each. In addition to the assessment outlined previously, students were encouraged to self-assess and reflect on their involvement in the group and contribution to the task. This reflection was considered a personal statement and was not formally assessed. Students were also asked to evaluate the process of PBL and its application to the chosen task by means of a short, anonymous survey, also not assessed. This post-topic survey revealed that they appreciated the departure from the traditional lecture format and practical work. Most reported that they derived a real sense of satisfaction on completion of the task and most enjoyed working as part of a team. Some students, however, reported a preference for working within known boundaries and were not as amenable to, independent, learning tasks such as this. This suggests the need for a more guided facilitation, however care is needed to avoid unnecessary interference. The students, in general, thought that they had enough time for their research and were able to find relevant information reasonably easily. However, as expected, they did find the topic rather dry but the novel approach tended to counteract this. Generally, students prefer individual marks rather than the allocation of a group mark. The decision to allocate a group mark for the presentation was based on the fact that a team project is just that, a team project, and, as such, should reflect the ability of the *team* rather than the ability of the *individual*. As a compromise, each student submitted an individual report for, which they were given an individual mark. Students tend to be quite amenable to peer assessment, and thus are willing to assign a mark to another group. Although results were not statistically analyzed, the students were, on average, in close agreement with the tutor as to the merits of each group's presentation. Overall scores were very similar although differences became more noteworthy when individual criteria were examined.

Initially students were wary of the self-assessment aspect, but rarely are students formally required to reflect in this manner and this could explain their reluctance. However, they came to realize that reflective practices have merit. Self-assessment

encouraged them to think about their work, their study habits, their contribution to the project and preferred mode of learning.

Academic staff

Staff members were most supportive and no obstacles were encountered. However, this may have been because they themselves did not actively have to play a part in this exercise. The onerous and time-consuming nature of the initial planning and implementation of the project have already been mentioned. By comparison, the assessment of all components of the task itself was not too demanding.

It is probably easier, after all, from a preparation viewpoint, for teaching staff to teach by means of lectures with notes and practical tasks. This is efficient teaching but it does not necessarily result in efficient learning. If active learning is to be fostered at tertiary level then alternative teaching methods have to be explored, and resources allocated to their implementation.

Future directions

The PBL task could be extended to cover applied topics other than clinical case studies. Modifications may be needed to cope with fluctuations in student numbers. This may necessitate recruiting more staff willing to be involved with the PBL process in order to keep staff/student numbers and time considerations to a manageable level. This, in turn, raises issues concerning consistency of assessment, necessitating further investigation and design refinements. In the work-place people are usually not free to choose their own working party team members. Therefore, in order to more closely align the task with the "real world" situation and make it truly vocationally-oriented, the group members should be randomly chosen.

Conclusion

Whether or not the use of PBL for the teaching of microbiology to pharmacy students will impact on the students' future studies and, as a result, their future examination performances, will be difficult to determine. As this exercise was worth 15% of the students' total mark, the topic was not assessed further as part of the examination, so any contribution to examination performance as a result of the PBL exercise would have been an indirect one. Indeed, it has been suggested that the evaluation of the PBL process needs some refinement.

PBL is a useful teaching tool and deserves a place in the teaching repertoire. No doubt the PBL technique would be useful in other areas of the course, but not necessarily as the main teaching technique. The chief value of PBL is as an adjunct to more traditional

teaching methods: To present students with an alternative teaching method that has as its focus, independent, active learning with peer group and tutor support, and to provide variety in the curriculum. Variety in teaching methods and a degree of flexibility are important as students have different learning styles. Efforts must be made to accommodate all students. Eagle et al. (1992) claimed that good tutors do make a difference. If the tutor is positive about the particular mode of teaching and has high expectations of the learning outcomes, these vibes will pass on to the students and they will perform accordingly. It is not so much the method used to deliver the material as the way, in which the material is delivered.

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References

- Abrahamson, S. (1998). Obstacles to establishing problem-based learning. *Journal of Dental Education*, 62, 656–659.
- Baker, Constance, M. (2000). Problem-based learning for nursing: Integrating lessons from other disciplines with nursing experiences. *Journal of Professional Nursing*, 16(5), 258–266.
- Barrows, H. S. (1986). A taxonomy of problem-based learning methods. *Medical Teacher*, 20, 481–486.
- Breivik, P. S. (1992). Education for the information age. *New Directions for Higher Education* No. 78, 20(2), 5–13.
- Cisneros, R. M., Salisbury-Glennon, Jill, D., & Anderson-Harper, Heidi, M. (2002). Status of problem-based learning research in pharmacy education: A call for future research american. *Journal of Pharmaceutical Education*, 66(1), 19–26.
- Duch, B. J. (1996). Problem-based learning in physics: The power of students teaching students. *Journal of College Science Teaching*, 15(5), 326–329.
- Eagle, C. J., Harasym, P. H., & Mandin, H. (1992). Effects of tutors with case expertise on problem-based learning issues. *Academic Medicine*, 67(7), 465–469.
- Ferrier, B. M. (1990). Problem-based learning: Does it make a difference? *Journal of Dental Education*, 54(9), 550–551.
- Herrier, R. N., Jackson, T. R., & Consroe, P. F. (1997). The use of student-centered, problem-based, clinical case discussions to enhance learning in pharmacology and medicinal chemistry. *American Journal of Pharmaceutical Education*, 54(Summer), 161–166.
- Hoffman, Elizabeth, A. (2001). Successful application of active learning techniques to introductory microbiology. *Microbiology Education*, 2(1), 5–11.
- Lancaster, C., Bradley, E., Camp, M. G., Chessman, A., Stroup-Benham, C. A., & Smith, I. K. (1997). The effect of pbl on students' perceptions of learning environment. *Academic Medicine*, 72(10), 10–12.

- Love, D. W., & Shumway, J. M. (1983). Patient-oriented problem-solving instruction in pharmacotherapeutics. *American Journal of Pharmaceutical Education*, 47, 228–231.
- Norman, G. R., & Schmidt, H. G. (1992). The psychological basis of problem-based learning: A review of the evidence. *Academic Medicine*, 67(9), 557–565.
- Pickrell, J. A. (1995). Enhancing large-group problem-based learning in veterinary medical education. *Teaching and Learning in Medicine*, 3(1), 28–32.
- Schmidt, H. G., Boon, L., Kokx, I., Moust, J. H. C., & Van Der Arend, A. (1993). Influence of tutors' subject-matter expertise on student effort and achievement in problem-based learning. *Academic Medicine*, 68(10), 784–791.
- Silver, M., & Wilkerson, L. (1991). Effects of tutors with subject expertise on the problem-based tutorial process. *Academic Medicine*, 66, 298–300.
- Sims, P. J. (1994a). Utilizing the peer group method with case studies to teach pharmacokinetics. *American Journal of Pharmaceutical Education*, 58(Spring), 73–77.
- Sims, P. J. (1994b). Utilizing the peer group method with case studies to teach pharmaceutics. *American Journal of Pharmaceutical Education*, 58(Spring), 78–81.
- Thompson, D. G., & Williams, R. G. (1985). Barriers to the acceptance of problem-based learning in medical schools. *Studies in Higher Education*, 10(2), 199–204.
- Vernon, D. T. A. (1995). Attitudes and opinions of faculty tutors about problem-based learning. *Academic Medicine*, 68(7), 550–563.
- Vernon, D. T. A., & Hosokawa, M. C. (1996). Faculty attitudes and opinions about problem-based learning. *Academic Medicine*, 71(11), 1233–1238.

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