INSTRUCTIONAL DESIGN AND ASSESSMENT

A Model for Self-Directed Problem-Based Learning for Renal Therapeutics

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Objective. To introduce a new approach to problem-based learning (PBL) for self-directed learning in renal therapeutics.

Design. This 5-week course, designed for large student cohorts using minimal teaching resources, was based on a series of case studies and subsequent pharmaceutical care plans, followed by intensive and regular feedback from the instructor.

Assessment. Assessment of achievement of the learning outcomes was based on weekly-graded care plans and peer review assessment, allowing each student to judge the contributions of each group member and their own, along with a written case-study based examination. The pharmaceutical care plan template, designed using a “tick-box” system, significantly reduced staff time for feedback and scoring.

Conclusion. The proposed instructional model achieved the desired learning outcomes with appropriate student feedback, while promoting skills that are essential for the students’ future careers as health care professionals.

Keywords: renal therapeutics, problem-based learning, case study, pharmaceutical care plan

INTRODUCTION

Problem-based learning, an important teaching tool within colleges and schools of pharmacy, has been expanded over the last 2 decades in America and Europe.^{1,2} Problem-solving capabilities, together with critical-thinking and decision-making skills, are crucial for pharmacists. Instructors within colleges and schools of pharmacy have an obligation to prepare students for this constantly evolving professional career, and PBL is 1 of the most widely recognized teaching models used to encourage the development of these skills and values.^{3,4}

The philosophy of problem-based learning was developed for medical students at McMaster University and is based on the analysis of health care problems as a process used to acquire and apply knowledge.⁵ Self-directed learning is the central element of the PBL-based learning approach, in which small groups of 5 or 6 students work together with the support of a facilitator.⁶⁻⁹ Students are required to gather and interpret information, and apply it to the scenario being investigated, helping them develop the problem-solving skills important for health care professionals.

Problem-based learning has gained wide-spread recognition, and several medical schools and some colleges and schools of pharmacy have embraced it within their curriculum.¹⁰⁻¹² In general, colleges and schools of pharmacy implementing PBL as a teaching method follow a combined approach with traditional educational techniques, where PBL is used for specific topics, such as pharmacy practice,^{13,14} therapeutics,^{15,16} and pharmaceuticals,¹⁷ whereas the remaining topics, particularly basic scientific subjects, are taught using traditional methods.

The use of problem-based learning as a central instrument of teaching has advantages and disadvantages. Advantages include: (1) presenting students with a more natural format for learning; (2) confronting many different resources to encourage critical thinking; and (3) promoting improvement of the student-tutor relationship.^{18,19} Students in a PBL environment spend, on average, 5 to 8 hours preparing each tutorial session. In contrast, students generally do not spend time preparing for a traditional lecture, with any related further learning usually carried out at a later time. Problem-based learning therefore is thought to provide a more natural format for the learning process. Development of critical thinking in students is 1 of the main desired outcomes of PBL which can be achieved in the right environment. Small group learning and the high staff-to-student ratio develops an intensive student-tutor relationship, assuring that learners receive the support they require.

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Nevertheless, there are also disadvantages connected to problem-based learning. These are based generally around administrative problems, rather than problems relating to the learning experience, and involve high costs and a high staff workload. PBL is a staff-intensive process, resulting in high staffing costs. Furthermore, it is difficult to assure that standardized, high quality tutoring is provided to each problem-based learning group, as the expertise of facilitators may vary.^{18,19}

This paper specifically addresses the curricular goal of designing a problem-based learning course in renal therapeutics for 100 students, which minimizes the impact on staffing resources, but still provides students with the experience of small-group problem-based learning. PBL is the teaching medium for all therapeutics courses within the school of pharmacy at the University of Reading, and the described renal therapeutics course is the first of a series which spans over nearly 3 years of undergraduate studies. A good introduction to PBL is therefore important to the students' experience.

Within this paper we report the implementation of problem-based learning as the central teaching element in our renal therapeutics course. Furthermore, we describe the introduction of an alternative method of providing problem-based learning, which attempts to overcome the disadvantages described previously without losing the main advantages of the traditional problem-based learning approach.

DESIGN

The renal therapeutics course at Reading school of pharmacy was a 5-week course that was the first part of the Therapeutics 1 module, designed for second year undergraduate masters of pharmacy degree (MPharm) students. The Therapeutics 1 module itself was the first of a series of therapeutics courses focusing on different organ systems. Renal therapeutics was taught as a PBL consisting weekly of 2 hours direct contact time with 1 to 2 academic staff members, and approximately 4 to 5 hours of self-directed study. The course, designed for a cohort of approximately 100 students, was based on the following learning objectives. After completion of the renal therapeutics course, students should be able to:

- Discuss and apply the concepts and principles of studying renal disease processes in humans and their consequences, including: markers of renal function, bladder function and control, acid-base and electrolyte control, and impact of renal impairment on drug therapy.
- Describe and understand the causes, etiology, epidemiology, and diagnosis of the most important renal diseases affecting humans, such as

acute and chronic renal failure and diabetes insipidus.

- Evaluate the treatment and management of patients who suffer from such diseases, including pharmacological treatment and renal replacement therapy.
- Analyze the mechanisms through which drugs act on the renal and urinary system, including the mode of action of diuretics and anti-diuretics.
- Give detailed examples of each disease process and relevant treatment options.

Initially, traditional problem-based learning was used as the main method of instruction for the renal therapeutics course. However, due to relatively high student numbers and limited staff resources, the ideally proposed staff-to-student ratio of 1:6 was not achievable, and a new PBL concept had to be developed. Furthermore, the MPharm course was subject to a rigorous accreditation process performed by The Royal Pharmaceutical Society of Great Britain; therefore it was important to ensure that the learning outcomes were appropriate and comparable for all students. We tried to de-emphasize diagnosis, and instead focus on treatment options and aspects of drug use and potential associated risks.

We developed a new learning format for the renal therapeutics course based on problem-based learning, followed by intensive and regular feedback from the instructor. The students worked in groups of 5 or 6 and were provided with the case study a week before the meeting.²⁰ Each group worked on the same case study on a weekly basis; in total, 4 to 5 different case studies were considered during the 5-week course. The whole cohort met once a week for a PBL tutorial with facilitators, which followed an organized routine that remained the same across the 5 weeks. The main outcome of each PBL tutorial was the design of a care plan which outlined the treatment of the patient described in the weekly case study and the potential pharmaceutical issues involved. Each group was responsible for deciding how and from which sources to obtain sufficient reliable information to complete the allocated task, designing a care plan for the patient described in the case. The students could use clerkship assessment forms, which facilitated the extraction of relevant information from the case studies, helping them prepare the care plan. This preparation took each student between 4 and 5 hours per week, depending on the case study and experience of the student.

The PBL tutorial began with 60 minutes of group work. During this time, the groups put together their final care plan and discussed with the facilitators any options or problems they encountered. These PBL tutorials were presented to 16 groups (each containing 6 students) and

2 facilitators, who were lecturers, practicing pharmacists, or postgraduate students.

After the 60-minute period of group work, each group submitted its proposed care plan, and the feedback session, led by the lecturer, then followed. During this feedback time the lecturer discussed the case study and design of the care plan, including possible treatment options and problems or issues to consider (ie, relevant drug interactions or required monitoring). Afterwards, the rest of the feedback session was used to highlight the important learning outcomes that students should have achieved through the group work and self-directed study completed while working on the case. This procedure ensured that all students were aware of the knowledge and skills that were expected of them. At the end of the PBL tutorial, the students were allocated their next case study. Table 1 shows a timeline of a typical PBL tutorial. Each was structured in the same way, which helped the students settle into a routine and maximize achieving the learning outcomes. Furthermore, each week-long PBL tutorial followed the same 5 steps, thus reinforcing the process of problem-based learning and critical thinking: (1) Students were presented with the **problem**; (2) Students **discussed** the problem within their small group. During this process they identified where gaps in their knowledge existed and formulated an action plan; (3) Students **engaged** in independent study; (4) Students met in groups to share information and **engage in peer teaching**; (5) Students **reviewed** what they had learned from working on the problem. Everyone who participated in the task engaged in self, peer, and tutor review of the problem-based learning process, and reflected on each person's contribution. The group's care plan was then designed and submitted, and was comprised of the best of the acquired knowledge of each group member.

In week 1 the students received a case study describing a patient who had been diagnosed with diabetes insipidus.

Within the group work and subsequent feedback session, the students studied the principles of renal physiology and the kidneys' multiple roles, as well as the pathophysiology and treatment of diabetes insipidus. Also within this session it was anticipated that the students would learn about clinical features and investigations of renal diseases. In preparation for week 2, the students received a case study detailing a patient with acute renal failure or chronic renal failure. Learning outcomes to be achieved in week 2 were summarized as the classification, etiology, and pathophysiology of renal failure, and in particular, treatment options and potential problems in acute renal failure (including the role of diuretics), and chronic renal failure (including renal bone disease). In week 3 the students were introduced to a variety of important renal diseases. These included obstructive uropathy (ie, kidney stones), infections of the urinary tract or the kidneys, glomerular disease, and polycystic disease. The case study provided to the students prior to the PBL tutorial dealt with 1 of these diseases and provided the basis to further discuss renal diseases. The case study for week 4 was based either on renal dialysis or kidney transplantation. The topic for the next PBL tutorial was renal replacement therapy; desired learning outcomes for week 4 related to renal dialysis (including hemodialysis and peritoneal dialysis), and transplantation (including preparation of donor and patient, surgery, and drug regimes). A typical case study scenario for week 5 was based on pharmacological and non-pharmacological treatment options for urinary incontinence. This last week of the course was used also to discuss the impact of renal impairment on drug therapy.

As an example of a PBL tutorial outlined above, during the session on renal failure (week 2), the students received a case study on acute or chronic renal failure 1 week in advance, to prepare for the PBL tutorial. At the beginning of the session, the students were given 60 minutes to design

Table 1. Typical Timeline for Each Case Study Presented in the Problem-Based Learning Model

Presentation of New Case Study	Preparation	Group work	Feedback	Group work
New case study is given to the students at the end of each previous problem-based learning tutorial	<ul style="list-style-type: none"> Individual research Individual study Group meetings 	<ul style="list-style-type: none"> Final discussion of research undertaken prior to this meeting Evaluation of research results from each individual group member Design and preparation of care plan 	<ul style="list-style-type: none"> General feedback with model care plan Feedback on learning outcomes that students should have achieved during the preparation period 	<ul style="list-style-type: none"> Presentation of a new case Assignment of individual tasks Arranging next meeting
	1 week	60 minutes problem-based learning tutorial	30 minutes	20 minutes

their care plan, consult facilitators, and discuss different options within their group before submitting 1 care plan. The facilitator gave immediate feedback to the students by presenting and discussing a model care plan, thus important learning outcomes were stressed. Students also received feedback on their individual care plans. The final 20 minutes of the PBL tutorial were used for the group to work on the next case study.

EVALUATION AND ASSESSMENT

Learning outcomes in traditional problem-based learning methods usually are evaluated and assessed by the tutor/facilitator through oral presentations and/or group interviews. This is staff intensive, and assessors require specialized knowledge to judge the students' answers. Within the described problem-based learning model, assessment was split into 2 types of assignments: graded care plans, and a written case study-based examination at the end of the academic year. A written examination is not ideal for a PBL environment, but it is a requirement of the degree accreditation process.

The problem-based learning grade for the renal therapeutics course was derived from the graded care plans (not including the first week's case). Each care plan was graded by a faculty member, and was used to provide individual feedback to each group on a weekly basis. The grades from the 4 assessed cases were collated, and in the last week, each student was asked to complete a peer assessment form. This aided the course leader in assessing the individual contributions of each group member, and was used to scale their overall problem-based learning grade. Peer review assessments are widely used in PBL courses and support the group work and peer teaching process.^{12,21,22}

The care plan template contained 5 sections comprised of patient details; drug history; diagnosis, problems, symptoms; pharmacological treatment options; laboratory data/vital signs; and key pharmaceutical issues. The grading scheme applied used a "tick-box system" with each correct answer giving the group 1 grade, while a wrong answer was given no score; no negative grade was applied. Within the category key pharmaceutical issues, individual scores were applied by the assessor to distinguish between the levels of answers given.

This method initially led to a comparatively high coursework grade that did not realistically represent the students' knowledge. Reflecting upon the initial design of the care plan, it was clear that certain parts were easy to complete (such as personal details and drug history), and gave the students the same number of points as the more challenging sections, such as treatment options and pharmaceutical issues. Therefore, the care plan was revised and different weightings assigned to each section, depending

on their complexity. For example, at the time of this writing, the treatment options section received 40% of the total grade, whereas the drug history and personal details sections received a lower weighting (15% and 5%). The implementation of these changes resulted in a reduction in the average grade for all care plans. The average care plan grade in the year 2009-2010 dropped to 64% (compared to 69% when the new weighted grading system was not used), with care plan 2 being graded at 59%, care plan 3 at 72.5% and care plan 4 at 60% (Figure 1). In addition to the different weightings, a penalty system was introduced for the 2009-2010 cohort, whereby a certain percentage of the total grade for each care plan was deducted for minor errors, major errors unlikely to cause significant harm to the patient, and major errors likely to harm the patient. Implementation of these penalties resulted in further reductions of the average care plan grades to 57% in week 2, 72.5% in week 3, and 50% in week 4, and the overall grade to 59% (Figure 2). Additionally, the average coursework grade was scaled according to the peer assessment performed by each group member to reflect individual contributions. The average coursework grade changed only marginally, but an acceptable spread of grades resulted, and each individual's grades represented their contribution to the group. They represented a realistic value for pharmacy coursework and were comparable to the average examination grade.

Faculty resources needed for the problem-based learning approach were low compared to traditional problem-based learning. Only 1 to 2 facilitators and a course leader were needed to support the learning and assessment process of approximately 100 students. Rooms which allowed group work for all 16 groups simultaneously, and that offered access to the internet and reference books were ideal. As all students worked on the same case study, only 5 different case studies had to be prepared, which is comparably low for a group of 100 students, also allowing

Figure 1. Average Course Work Grade: Comparing the New and Old Grading Scheme for the 2009-2010 Cohort.

Figure 2. Average Course Work Grades (2009-2010) for Care Plans in Weeks 2, 3 and 4 (Care Plan 2, 3, and 4) and the Overall Average, With and Without Penalty System

updates and changes to the case studies to be made easily every year to remain current, and reducing the risk of plagiarism.

DISCUSSION

Crucial to the success of the problem-based learning process is that an appropriate case study is chosen, and that it is presented to provide the students with enough information for them to be able to complete the case, without leading them directly to the correct answer. Within our choice of case studies the following criteria had to be fulfilled. Each case had to be chosen carefully to assure that the intended learning outcomes were achieved by the students. Additionally, assuring that the description and content of the cases were relevant to pharmacy students, who have different requirements than medical students, was important.^{2,23} For pharmacy students, the main focus is the treatment of the disease, rather than the diagnosis. Nevertheless, the diagnosis is part of the students' work on the case studies at an early stage, to involve them in the patient's situation and help motivate them. Seeing how well the students engage with the case is both interesting and rewarding. As for difficulty level, traditional problem-based learning approaches require all case studies to have a similar difficulty level. This is not necessary for the PBL approach described above, as every student works on the same case study and the level of complexity should increase from week to week. The case study must focus on the material intended to be taught. For this reason, only cases of isolated renal disease were chosen, as treatments relating to the other organ systems are taught at a later stage in subsequent therapeutics modules. Finding cases in which renal disease is an isolated problem is challenging, as it is often a result of other preceding imbalances in the body. Nevertheless, it is easier for the students to look at an

isolated case, especially as this module is the first time they encounter the case study format.

The facilitator is also crucial to the success of a PBL environment. The role of the facilitator in the traditional problem-based learning approach, as well as in the approach described within this paper, is to support students with their group work and the PBL process, rather than to act as a resource for questions and unknown details.²⁴⁻²⁷ The students' acquisition of this knowledge, and the processes used to obtain it, are important to the problem-based learning method. Therefore, the facilitator does not need expertise within the area, as long as the case studies and care plan have been designed with the support of a specialist. Indeed, not being a specialist may be advantageous, as it is easier to resist any subject-specific questions raised by the students. Within the proposed PBL tutorials, normally the lecturer and a practicing pharmacist are present, supported by a postgraduate student. The demands of the 16 groups can be satisfied without major problems. Using this approach, the groups were generally well prepared and required minimal input from the facilitators.

The first problem-based learning tutorial was different from the subsequent ones, as the students had not encountered this style of teaching before, and therefore required an introduction to the concept and what was expected of them. Furthermore, they had not received a case study prior to the meeting and were not aware of the format to be used for the pharmaceutical care plan. Therefore, this first meeting started with a simple case study, which was completed during the session, using material covered in the physiology module that preceded the course, together with textbooks and internet resources which were available. Students spent the majority of this session learning how to complete the care plan correctly. This first exercise was not graded, but was used to motivate the students and provide them with a direct introduction to problem-based learning. The students learned rapidly, enjoyed the learning environment, and the outcomes were usually good, even at this early stage. General mistakes were addressed in the subsequent feedback session, and individual written feedback was given to each group during the week.

The significant advantage of the discussed course is that students experienced a problem-based learning experience in small groups, but only a limited number of staff was necessary to enable this learning experience. All students worked on the same case studies, and therefore uniform knowledge gain could be expected. Only 5 case studies had to be prepared each year, therefore the change of case study scenarios was simple, and plagiarism was kept to a minimum. The risk of plagiarism did exist, but no problems have been experienced to date. Furthermore, the proposed model allows new case studies to be designed

every year, as we have seen that plagiarism is more prominent among different year groups rather than within the same year group. Using this approach, students work on a new case study every week, resulting in a relatively fast turnaround of case studies, with the anticipated high learning output achieved. The groups receive direct and individual feedback every week; these feedback sessions also assure that every student is aware of the expected learning outcomes. Also, using the care plan template encourages a logical approach and provides preparation for the type of paperwork that may be encountered in practice, particularly in the hospital sector.

There are potential weaknesses to this teaching format. One is the lack of fixed roles within the groups, such as group leader, minutes recorder, and presenter, which is often a part of traditional problem-based learning approaches. Nevertheless, introducing these structures would be possible, if deemed necessary. Unfortunately, students are not required to present their work orally, reducing the ability to assess their communication skills. However, their completion of the care plan can be used to show the outcome of their group work, and to assess their written communication and application, using a logical approach. Another criticism may be made that the proposed PBL model contains a high workload for the students. This would need to be considered individually within each college or school of pharmacy, and appropriately addressed. Nevertheless, the workload for the facilitator and other academic staff involved is reduced, therefore addressing 1 of the major problems associated with traditional problem-based learning approaches.

Although the knowledge gained through the therapeutics modules are a major part of the MPharm program, the skills that students develop through the problem-based learning process are perhaps the most important outcome of the course, and are essential for their future professional careers. Information handling, communication, organization, teamwork, and time management are transferrable skills that clearly will be of benefit to them as members of the health care team. Acquisition, prioritization, assimilation, and interpretation of information are important to the work of a pharmacist, whether when recommending a product based on a patient's symptoms, interpreting a patient's hospital medical notes when clinically screening their prescription chart, or researching information when answering a medication-related query. Communicating with their peers and academic facilitator will contribute to their ability to respond appropriately to patients with a range of needs. Group work will help prepare them for working as part of the health care team, while the logical approach required for the PBL process will help with their problem-solving skills.

Continuing professional development may become a legally mandatory requirement for registration as a pharmacist in the United Kingdom. During the problem-based learning method described, students are required to consider the knowledge they already possess about the case topic; identify areas in which they need to develop; agree on a plan for achieving this; carry out tasks to obtain the information required; and finally, as the care plan is formulated, evaluate whether the group has been successful in completing the task. Such an approach may be applied to the continuing professional development process, with parallels drawn with the stages of reflection, planning, action, and evaluation.

At the time of this writing, the renal therapeutics course had been offered for 3 consecutive years in this format, with adjustments made each year to improve the learning process. Different case studies have been tested and developed. The introduction of a clerkship assessment form, used to summarize and collect data in a clinical setting during the admission of new patients, has helped the students extract relevant information for the care plan. The introduction of the weighting scheme and the penalty system were particularly important modifications made to reflect the learning progress of the students. Comparing the average coursework grade from the 2008-2009 cohort, where no weighting or penalty system was in place, to the 2009-2010 cohort, a drop in the average coursework grade from 72% to 59% was seen. This grade better represented the actual knowledge level of the students as shown in the case study-based written examination.

In general, students engage well in a problem-based learning environment regardless of the model used. To evaluate the new problem-based learning model described, every student had the opportunity to complete a feedback form at the end of the course. The feedback showed that students enjoyed the new learning experience, and negative comments mainly concerned group allocations and the amount of material taught within the course.

CONCLUSION

The new problem-based learning model has been established as an effective alternative and a welcome change to the traditional problem-based learning approach, enabling students to develop skills including teamwork, communication, critical thinking, problem solving, and independent learning, attributes that are crucial for future professional careers. The emphasis of learning is on the students, and they voluntarily spend many hours preparing for the sessions, more than for traditional lectures. Nevertheless, the workload for the facilitator and other academic staff involved is reduced, therefore addressing a major problem associated with traditional PBL approaches. The

proposed model has been tailored to large class sizes, and the method of assessment leads to the achievement of realistic grades.

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