[O18] The integration of problem-based learning into a traditional teaching framework – lessons on mixed economy models of education

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Keywords: biochemistry, simulation software, problem-based learning

ABSTRACT

Many medical undergraduate courses have moved towards problem-based learning methods. This is in contrast to many UK HE undergraduate pure science courses where tutor-centred approaches still predominate. The model used for undergraduate medical courses may be successful due to several factors such as the motivation and prior achievement of the students. This may discourage tutors on courses, which recruit with the philosophy of broadening access, from attempting to integrate PBL into the curriculum.

The authors have integrated some problem-based learning into the standard curriculum of a second level undergraduate biochemistry module, looking at proteins. The typical cohort for the module is quite diverse, including full-time undergraduates in biochemistry, molecular biology as well as HNDs in biochemistry. A small cohort of part-time HNC students in biology and biochemistry also access the course.

We have replaced the teaching of two areas of the curriculum, enzyme kinetics and protein purification by problem-based learning. Basic principles have been articulated in keynote lectures and the students have then been set a related problem-solving task using published software. The tasks are set as assessable parts of the module and a key to the formulation of this approach has been to use assessment criteria that ask the students to demonstrate understanding at a deeper level than the lectures and then apply that understanding to solve a problem related to enzyme purification and the determination of kinetic parameters. Threshold grade criteria for borderline first class and pass grade work are articulated to the students to emphasise the need for a deeper understanding of the physico-chemical principles underpinning the application of the methods to be learnt. The use of texts, internet sources and published literature to support the work is encouraged.

Assessment of understanding is made via the assignment and also in formal time-restricted tests. The approach has met with limited success and has pointed the way to interesting questions around tutor and student centred approaches to teaching.

INTRODUCTION

McMaster University in Canada introduced problem-based learning (PBL) into medical school curricula in 1963 (see Neufeld and Barrows, 1974). The driving force in PBL in medical degree courses was a desire to contextualise learning in supporting disciplines, to move to a student centred approach and to develop team-working skills. Student Motivation was seen to be improved by this approach. However, the extensive use of regular small-group tutorials makes the medical approach expensive and difficult to manage with large cohorts.

One way of resolving this dilemma is to utilise technology to support the problem-based learning aspect of this course. This has the advantage that tutor input is reduced, as the student makes more use of the IT interface. There are several considerations in adopting this approach. One is the need to ensure that the student is engaging sufficiently with the curriculum in order to achieve learning. Two, is that there is an enormous input in creating suitable high-quality IT-based teaching materials to support the student. This may involve not only creating text for learning but self assessment materials to check the achievement of learning by the student. Three, must be due consideration in making sure that collusion between students has not taken place in the preparation of materials for assessment.

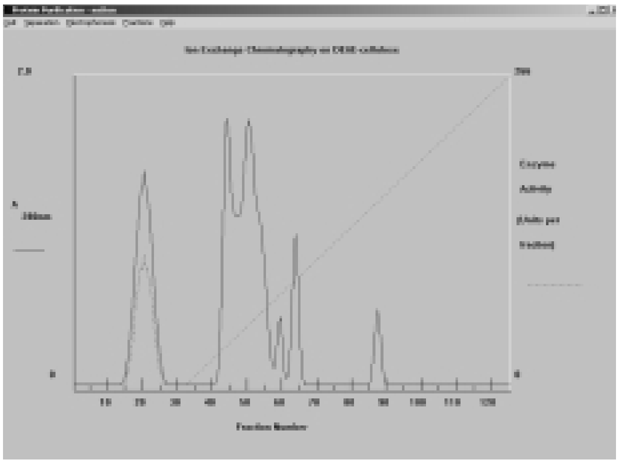
These issues can be addressed by creating situations within a student cohort where tasks such as case studies and problem solving are made individual to the specific learner. With the conventional case-study approach to PBL this would require an enormous input into the development of a bank of case studies that could individualise learning. Software that is designed with end user interfacing to create banks of similar case studies can allow for this. Simulation software is one of a range of tools that can contextualise learning, test understanding, and apply knowledge. The combination of the use of simulation software with assessment as a driver for achieving understanding can create a powerful tool for PBL.

The ProteinLab software that is part of the eLABorate series of programmes, written by Andy Booth, was used as the basis for delivering the PBL. The approach described here differed from the facilitator-led methodology and case-study approach that has been successfully applied to medical degrees. The ProteinLab software allows the user to simulate a protein purification. The advantages of simulation software in undergraduate programmes include the reduction of real-time by the student than could be achieved by practical hands-on experience of the methods, thus experiencing of a wider range of techniques than would be possible to provide within the standard undergraduate curriculum and the development of experimental planning and application skills. In the past this area of the undergraduate biochemistry curriculum has been taught as part of a module in a traditional lecture / tutorial format.

The software is well designed with extensive help pages on purification strategies and each of the separatory and analytical techniques that can be utilised to purify a protein from custom-designed mixtures. Students can learn how to purify a protein by reading the strategy page. They can then learn about the use of each individual purification technique by studying the pages describing the use of that technique. The student can then set up a purification using one of the techniques. The results of each separation can be expressed as an electrophoretogram or chromatograph and the location of the protein that the student is trying to purify identified using immune or enzyme assay. A typical result of such a purification step is shown in figure 1. The progress of a purification protocol can be followed, using either SDS PAGE coupled with immunoblot identification or specific enzyme activity.

The two main reasons for adopting a different approach are, that there is a need to reduceto reduce the staff loading implied by PBL and that TSL could be used to develop independent learning by the individual. Despite these differences, the approach described here emphasises the responsibility of the individual as an independent learner. This approach meets nearly all of the PBL precepts in Kivela and Kivela (2005) but does not concord with all of the characteristics described in Rosing (1997). Comparative aspects of this are discussed later.

Figure 1: Screen dump of ion exchange chromatograph from the ProteinLab software package



SOURCES OF PROGRAMMES

The proteinLAB part of the eLABorate software suite is available to educational institutions from: http://www.york.ac.uk/depts/chem/staff/elaborate/packages/obtain.html.

The enzyme kinetics is part of the biochemical simulations suite of software from DAB computing via d.bender@ucl.ac.uk.

METHODOLOGY

The PBL approach was integrated into a module largely delivered by the standard lecture/tutorial approach. This second year undergraduate module, entitled 'Proteins' covers protein and enzyme purification, structure and function to biochemistry and biology students. Typically the class size is about fifty students.

A short introductory session on the basics of the software showing how students could access the programme and some of the main analytical features was placed at the end of a lecture session and at the same time a list of criteria used in assessment handed out. The assessment criteria were expanded with some guidance as to what would be expected in an exemplary piece of work. Each student taking the assignment was given a different protein from the mixture to purify to reduce the possibility of collusion between students. Students were given five weeks to work through the strategies and produce a final report that was to be written up in the style of a practical report. The students were given free rein to approach the tutor if they needed reassurance on the progress that they were making.

The software has the facility to make banks of mixtures of proteins with up to 20 proteins in any one mixture. A file bank of three mixtures of twenty proteins was created each with parameters that allowed observation of the mixture. Thus, an individual protein could be made of one or more polypeptides with any stoichiometry desired. For the purposes of the learning experience the molecular weight range of the polypeptides must fall between 6 and 80kDa and isoelectric points must lie between pH 4 and 9. The use of this software by the student was linked to an assignment where the explicit criteria for marking underpinned a philosophy that used assessment to drive the necessary learning needed in order to successfully complete a protein purification. For example, some of the assessment criteria relate to the student using the method appropriately:

(i) Explain the tools used to analyse the outcome of each stage of the protein purification protocol in your methods section.

(ii) Use the techniques of protein purification appropriately to purify an individual protein from the protein mixture.

Each of the criteria was assessed by using a grade to describe the student performance. An example of marking criteria related to assessment criteria (i) described above is

Table 1: Grading criteria used to match to assessment criterion 1

Criterion	E/F	D	C	B	A
Description of Purification Techniques	Criteria for a D grade have not been met.	Principles of one technique is described showing some understanding of the method *or* material is largely transcribed showing limited understanding.	Principles of some techniques used are described in the student's own words showing good understanding of the method.	Principles of all techniques used are described in the student's own words showing good understanding of the method.	Principles of all techniques used are described in the student's own words showing clear understanding of the method.

shown in table 1 overleaf.
A is equivalent to a first class performance in the criterion being assessed. This transparency in the assessment process serves as an initial motivating factor for the students.

The module timetable was then redesigned to remove all but a basic introduction to the programme delivered in one of the lectures. In this topic no coverage of appropriate purification strategies was given by lecture with the space created by the removal of the lecture and tutorial used to allow students the time to achieve learning and undertake the assessment task.

In the final report students had to write, in their own words, an explanation underlying the physico-chemical principles of the purification methods that they had used. The methods section guidelines were that all parameters in choosing the separatory technique were described. Students were expected to show chromatographs of their purified protein and use SDS PAGE to calculate the molecular mass of the subunits of their protein. The students were asked to include in an appendix descriptions of separatory methods that had been discarded. This was related to the discussion section of the report in which a justification the choice of purification protocol used was required.

The design of the assessment parameters mirrored these assessment requirements closely. The mixture of knowledge required in the introduction, practical design and justification were used as basic indicators of learning achieved.

In addition to check that scientific principles learnt in this exercise were retained in the long term the principles of some of the methods were assessed using a formal time-restricted test.

EVALUATION

The way in which students learnt could be assessed by their success in applying the techniques. In the three years that this approach has been adopted no student has failed to purify their protein from the mixture and no student submitting an assignment failed the assignment. These marks compare favourably with the average marks achieved when this syllabus area was assessed using conventional time restricted tests. This implies that the correct methods must have been learnt from the help pages in the programme. The student view of this approach to learning was obtained by means of questionnaires and interviews. The students all complained about the workload. Comments such as 'Learning stuff yourself is very hard' or 'I had to spend a lot of time reading and rereading the help pages' were common. In module evaluation questionnaires, the module was rated as difficult when compared to other modules

Table 2: Task based PBL vs. the traditional PBL as described in Kivela and Kivela (2005)

Task based	**Traditional**
Curriculum/syllabus as experience	Curriculum/syllabus as experience
Student/learner-centred	Student/learner-centred
Coherent and relevant	Coherent and relevant
Teaching as facilitating information	Teaching as facilitating information
Learning as constructing	Learning as constructing
Flexible learning environment	Flexible learning environment
Low tutor input	High tutor input

being studied at the same time. However, grades for the problem-based learning exercise were well above those obtained for most other coursework items on this module and on others.

One of the aims of this more student centred approach was to encourage deep learning and the students were asked to compare their feelings about the learning using this approach with those that had taken place on other parts of the module taught by traditional means. The typical comments were 'I found that I really understood what separation techniques could be used for whereas with other stuff you learnt it for the test and then it was quickly forgotten' or 'although learning by this approach was hard you felt you had really got to grips with this by the end of the module'.

Tutor evaluation was attempted through a qualitative appraisal of a range of student grades to see how well the full ability range of students coped with this learning method. Those students obtaining good grades down to second-class showed no lack of understanding in their use of separation tools. Typically, the learning of weaker students exhibited superficial responses to parts of the assignment. This was manifest in the level at which the assignment was attempted with less than full description of the methods used and in some cases not all methods being applied appropriately to a purification step.

OUTCOMES OF THE APPROACH

A main feature of the approach to PBL is the use of TSL to replace tutor support in the learning process. The rationale for this is two-fold; firstly the reduction of tutor-directed input allows the tutor to address other aspects of the learning experience within the module and secondly it encourages students to work independently. The other main difference between this and the PBL approach adopted in medical faculties is that the learning was linked to a simulated practical rather than a case study. Thus the approach could be described as Task-based PBL rather than Case-study based. In many other respects the approach adopts similar values to those espoused in traditional approaches. If we compare table 1 in Kivela and Kivela (2005) with ours we see concordance (see table 2) and a great deal of commonality to the characteristics of PBL described in Rosing (1997) and shown in table 3 on page 106.

In terms of the approach to integrated PBL that has been extensively described (see Jervis and Morris, 1996; Harris *et al*., 1997) this approach differs in that it can be integrated into a conventional curriculum with little need for adaptation of the other teaching methods used on the module.

In some ways it more closely follows the case study approaches that are described in Rivarola and Garcia (2000) and Rosenblatt (2003) and the problem-based learning approach of Whitely (2000) as applied to enzyme kinetic analysis.

Table 3 Comparison of general characteristics of task-based and case study learning programs as outlined in Rosing (1997)

Task-based	**Case study**
Student centered	Student centered
Students need little input from tutor	Teachers work closely with students
Learning objectives	Learning objectives
Teachers provide scenario	Teachers ask questions
Short-term memory	Long-term memory

PROJECT DEVELOPMENT

The scope for broadening this approach is very much based upon being able to resource the development of software. The advantage that we had was to beto ablebe able to use the sophisticated software developed by Andy Booth. We have expanded this approach into the teaching of enzyme kinetics using a similar approach to the one described above. However, in the kinetics tasks the problem-solving approach was based upon David Bender's kinetics simulation programme. Individualisation was a little more difficult as there is no facility with this software to custom-design a larger range of enzymes for kinetic analysis. However, at least ten different kinetic analyses could be tried with this software. Another limitation of this software is the lack of being able to do multi-substrate kinetics making its use beyond second level biochemistry courses limited.

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