

Using innovative group-work activities to enhance the problem-based learning experience for dental students

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Keywords

active learning; dental education; group work; problem-based learning; PBL assessment.

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Accepted: 22 January 2009

doi:10.1111/j.1600-0579.2009.00572.x

Abstract

Problem-based learning (PBL) in medical and dental curricula is now well established, as such courses are seen to equip students with valuable transferable skills (e.g. problem-solving or team-working abilities), in addition to knowledge acquisition. However, it is often assumed that students improve in such skills without actually providing direct opportunity for practice, and without giving students feedback on their performance. 'The Manchester Dental Programme' (TMDP) was developed at The University of Manchester, UK as a 5-year, integrated enquiry-led curriculum. The existing PBL course was redesigned to include a unique, additional PBL session ('Session 4') that incorporated an activity for the group to complete, based on the subject material covered during student self-study. A summative mark was awarded for each activity that reflected the teamwork, organisational and overall capabilities of the groups. This paper describes the different types of activities developed for the Session 4 and presents an analysis of the perceptions of the students and staff involved. The student response to the Session 4 activities, obtained via questionnaires, was extremely positive, with the majority finding them fun, yet challenging, and 'worthwhile'. The activities were perceived to enhance subject understanding; develop students' problem-solving skills; allow the application of knowledge to new situations, and helped to identify gaps in knowledge to direct further study. Staff found the activities innovative and exciting learning tools for the students. The Session 4 activities described here are useful educational resources that could be adapted for other PBL courses in a wide variety of subject areas.

Introduction

Problem-based learning (PBL) is an educational methodology promoting student-centred learning; it allows students to explore and set their own learning agendas within a structured environment (1). The use of PBL in medical curricula was introduced by McMaster University in Canada in 1969 (2) and has since been enthusiastically adopted by an ever-increasing range of disciplines and educational settings (3–9), including dental curricula worldwide (10–12). At The University of Manchester, PBL was introduced for the basic biosciences in 1994 for year 1 of the 5-year Dentistry course (13) and was later developed for year 2 in 2000. The process was described as a 'closed loop' or reiterative style of PBL (14, 15), allowing students to start with a clinical problem or scenario and after a period of self-study, re-visit the problem in the light of knowledge gained. The central 'problem' to be explored was an area of study or topic rather than a problem to be 'solved' (Fig. 1; 15).

The original Manchester format of PBL aimed to provide the students with a sound comprehension of the differing subject areas whilst affording them the opportunity to develop transferable skills associated with PBL (communication skills,

problem-solving, lateral thinking and teamwork). Knowledge acquisition from PBL was assessed by traditional summative examinations at the end of each semester (i.e. in January and May). However, assessment of the extended skills of PBL was inadequately addressed: a single overall 'PBL mark' awarded by the group facilitator was added to the summative assessment marks to reflect individual contributions in PBL sessions. Formative assessments and opportunities for the students to ascertain their own level of understanding of topics during the semester were not readily available.

An internal review at The University of Manchester allowed academics and clinicians to enhance and enrich the Dental curriculum. 'The Manchester Dental Programme' (TMDP) was re-designed as a 5-year, fully integrated enquiry-led curriculum. The new course was adopted for years 1 and 4 in the academic year starting September 2006, for years 2 and 5 in 2007 and was completed for year 3 in 2008. The classes, where possible, were organised with students from other oral health science disciplines and comprised students from cross-year groups. The new programme includes PBL, laboratory classes (practicals, dissection and technical materials), clinical skills and computing as before but gave us the opportunity to develop and

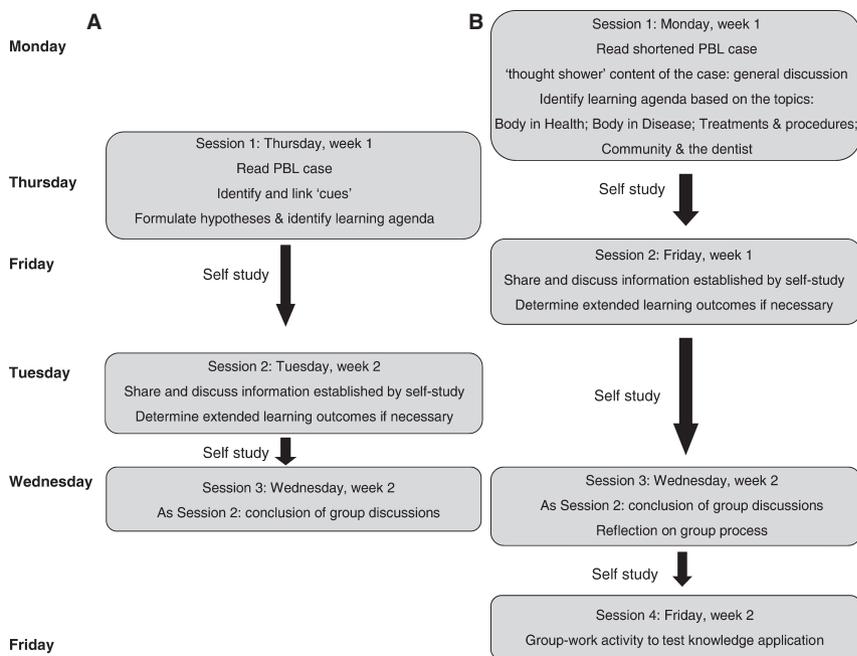


Fig. 1. Flowchart showing the original (A) and new (B) problem-based learning (PBL) processes for year 1 dentistry at The University of Manchester, UK. The PBL cases in the original format span 1 week in comparison to the new process whereby the cases extend for 2 weeks.

improve all aspects of delivering the curriculum for the new generation of dental students. Didactic lectures were replaced with a weekly 2-h symposium that was delivered by both academics and clinicians. PBL groups were reduced in size to just eight students, which is the optimal size recommended for PBL (16). Case scenarios were shortened, although cases now encompassed a wider subject area, and the length of time allowed for self-study increased; each case now spanned a 2-week period, meeting as a group four times, with an emphasis given to group and self reflection at the end of Session 3 (Fig. 1). The learning agenda was based on the headings 'body in health'; 'body in disease'; 'treatments and procedures' and 'community and the dentist'. An overall syllabus was available to students on their virtual learning environment. However, the specific learning outcomes were derived by the students and monitored by the facilitator during the PBL sessions.

A major alteration to the organisation of the PBL was the introduction of a novel PBL session. This unique 'Manchester PBL Session 4' (Session 4s) incorporated an activity for the group to tackle (see later for a description of the activities), based on the subject material covered in the preceding 2 weeks. The students were thus able to apply their knowledge gained from studying PBL cases to other scenarios or problems. Groups were not given details of the activities prior to the session, thereby encouraging effective teamwork, lateral thinking and allowing the development of problem-solving in limited-time situations. The activities varied for each case so that all students would have the potential to excel, depending on individual capabilities and learning preferences. In addition, it was hoped that the Session 4s would allow students to gain formative feedback regarding their level of understanding of the PBL topics, by assessing how well they could complete the tasks. It was anticipated that students would be able to identify areas that they had perhaps missed, any areas of weakness or gaps in their knowledge following their self-study. A mark was awarded for each Session 4 activity that

reflected the teamwork, organisational and overall capabilities of the groups. These marks were used as part of the individual's summative assessment for the year.

This paper describes the different types of activities developed for the innovative PBL session in Year 1 and presents an analysis of the perceptions of the students and staff that participated in the launch of the novel Manchester Dental PBL Session 4s.

Methods

Eighty-one students entered year 1 of TMDP at the start of the academic year in September 2006. The majority of students was classified as Home/UK students (95%) and were aged under 21 (84%) on entry. Eight per cent of students were graduates and 15% entered after completing a pre-dental foundation year in basic biosciences. The average Universities & Colleges Admissions Service points score from the UK A level students was 29.66. Female students (57%) slightly outnumbered males (43%).

Session 4 activities

The activities in year 1 covered 11 different subject topics relating to the theme of the oral cavity, digestive system and nutrition. These topics included tooth morphology, caries risk assessment, muscles, saliva, swallowing, basic pharmacological principles, diabetes, pancreas, liver, kidney and bowel functions and dysfunctions. These topics were explored using the activities described below. The activities were either tackled as a whole group ($n = 8$), or in smaller sub-groups of four.

The session 4 activities had several intended learning outcomes including testing understanding of subject knowledge, development of team-working, lateral thinking, and problem-solving abilities and encouragement to think in a logical, organised manner. In addition, some activities emphasised the development of a logical approach to the diagnostic process,

interpretation of graphical or tabulated data, and introduction to the concept of critical appraisal when interpreting published scientific research. Seven types of activity were used: 'information soup'; blunder case; drip-feed diagnostics; journal club; data-handling; happy families and a picture quiz.

'Information soup' exercise (whole group exercise)

Topics: caries risk assessment; bowel function

Different pieces of information were distributed amongst the group. Each person was given one or two pieces of information that they had to share to complete the task. The task/problem was outlined in one of the pieces of information, so the first stage in this exercise was to ascertain what the problem was and how it needed to be reported to the tutor. The organisation of the information flow, interpretation and relevance of the information needed to be managed efficiently, in order for the task to be completed within the 55 min time-frame.

Example task: Considering the information given, who (Margaret or John) do you think is more at risk for developing caries? Give reasons with full scientific explanation. What assumptions have you made to arrive at this answer? What advice could you give to help improve the oral health of the children? You have 30 min to arrive at your decision and then 10 min to report back orally to your tutor.

Examples of information available:

Birthday card showing John is 4 and where he lives.

School report showing Margaret is 6 and her home address.

Map of UK and map detailing where areas of high fluoridation occur.

Tooth-cleaning routines and toothpaste preferences of the children.

Socio-economic information about parents.

Pre-natal and early childhood factors.

Dental chart showing current oral status (and confirming children's ages).

Typical daily menus for the children.

Fluoride content of different foods.

Blunder PBL (whole group exercise)

Topic: pancreas

This was a short clinical scenario designed to be read and discussed, to mimic a standard 'PBL' case. The case was on one aspect of the topic that had been studied by the students during the preceding weeks. However, the case contained eight mistakes or inaccuracies that had to be identified and corrected by the group.

'Drip-feed' diagnostics (whole group exercise)

Topics: muscles; swallowing; kidney

These exercises were designed to help the students develop a logical approach to the diagnostic process, starting with taking a patient history and working up to requesting expensive or invasive medical tests. The students were presented with a short

clinical scenario and had to decide on a potential diagnosis by asking for further information and/or tests as a clinician would in medical practice. The tutor had been given a range of information, some of which may or may not be relevant. The students had to request information, one piece at a time, in a logical order, arrive at a suitable diagnosis and treatment plan and be able to justify their choices.

Example problem: Mrs Readshaw, a 30-year-old teacher, presented to the A&E department complaining of a dull, aching pain in her left side and bouts of shivering, headache and vomiting.

As an A&E doctor, you must obtain the appropriate information from your patient (i.e. your tutor) and ask for the relevant test results (from your tutor) that you require for making a diagnosis. You can ask for one piece of information at a time (try to be logical in your approach) and complete the answer sheet provided. After making your diagnosis suggest the treatment and advice you would give this patient. You have 30 min to complete this task, including presentation preparation.

At the end of the session, you will have to present your diagnosis to the tutor, justifying why you asked for each piece of information and how it helped in your differential diagnosis, and explain your treatment plan. You have 10 min for this presentation.

Examples of information held by the tutor: past medical history, current symptoms; clinical examination, urinalysis, urine microbiology, blood tests for full blood count, for urea and electrolytes and for gases, kidney function test, intravenous urogram/pyelogram, pregnancy test, and bone density.

Journal club (sub-group exercise)

Topic: diabetes

Prior to the group work session, the students were directed to retrieve and read a particular paper from a peer-reviewed scientific journal. In the session, the students were given a series of questions on individual cards based on the content of the article; some questions were harder to answer and thus 'worth' more marks than others. The students worked in teams of four to answer as many questions as they could within the time allocated in order to gain the most number of marks. Students who had read and digested the article prior to the session were at an advantage to students who had not prepared for the session.

Data-handling exercises (sub-group exercise)

Topics: saliva; pharmacology

Students were given tabulated or graphical data from practical experiments and were expected to answer questions and present data based on their interpretation of the results.

Happy families (sub-group exercise)

Topic: liver

Students were given numerous cards with different types of information (e.g. histology slides, enzyme levels, images of

organs or tissues etc.). The students had to decide appropriate family groups that the cards could be sorted into and be able to explain the connection between the cards. In this instance, the students had to determine the following family groups: haemolytic disease of the newborn, biliary obstruction (gallstones), infectious disease (hepatitis C), fatty liver disease and normal liver.

Picture Quiz (sub-group exercise)

Topic: tooth morphology

Students were given cards with individual pictures of permanent and deciduous teeth. Students were asked to reproduce the dental chart for an 8-year-old boy and were asked to pick out the cards representing the teeth that would be present.

Tutor role and marking of Session 4 activities

Tutors were given full instructions regarding the Session 4 activities, including a time-plan for the session (Fig. 2). The answer was also provided with explanatory notes. Marks were awarded by the tutor of 0 (poor), 1 (satisfactory) or 2 (good) for the following criteria: initial approach to the task; organisation of group/time management; equal participation of all individuals; utilisation of acquired knowledge; quality of task completed. Students were informed of the mark at the end of the activity together with verbal feedback. Each individual student carried the mark forward as part of their coursework mark for the year. As some activities were performed in smaller sub-groups, the members of which changed for each activity, students did not all accrue the same mark. The Session 4 activities contributed two-thirds of the overall coursework mark.

Evaluation of Session 4 activities

Feedback regarding students' opinions of the Session 4 was sought via questionnaires at the end of the year in May 2007.

Questionnaires were returned by 71 students (88% return rate) with a demographic mirroring the cohort overall. This was considered adequate to give meaningful data. Students were given a series of statements for which they were asked to respond with either 'strongly agree', 'agree', 'neutral/no opinion', 'disagree' or 'strongly disagree'. Data were combined into three opinion categories of 'agree/neutral/disagree' and are presented as the percentage of respondents. Staff ($n = 10$) opinion was sought via informal round-table discussions at the end of both semesters.

Results

The questionnaire delivered to students sought opinion on whether the Session 4s had achieved the aims of supplementing PBL and development of transferable skills. In addition, general student opinion of the activities was sought. Each of these three areas will be considered in turn.

Session 4 activities as a supplement to PBL

One of the major aims for introducing activities of this nature to our programme was to allow students to apply the knowledge they had recently gained to alternative problems or scenarios. The majority of students (80% of respondents) agreed that the Session 4 activities had allowed application of pre-existing knowledge to alternative situations (Fig. 3A). Although one student did comment that '[I] sometimes felt as if Session 4 activities were unachievable, and I left feeling more depressed about how little I knew'. However, the majority of students were of the opinion that these activities had further enhanced their understanding of the subject matter and importantly, identified specific areas where further individual study was required (54% and 51% respectively; Figs 3B,C). One student remarked that the activities 'had encouraged me to read around the subject more' and that he/she had been able to 'draw knowledge together and helped me to put knowledge into use'. In addition, a number of students observed that the post-activity discussion and feedback between the tutor and the group proved to be a valuable feature of the sessions.

30 min task

10 min report back results + for questioning if needed

10 min feedback to group on their performance

5 min collect in resources

This 'information soup' exercise is designed to test the students' understanding of the complexity of risk factors for developing caries. In addition the students will gain experience of working as a team and developing problem-solving and lateral thinking abilities.

This task will be completed as a whole PBL group. There are 14 pieces of information to be shared out amongst the group – the numbering of the items is for ease of administration and has no relevance for the task.

One item (item 13) details that task, but the students have to work this out for themselves (you may want to give this card to a quiet member of the group to encourage them to speak out and take a lead). The students have to share their information, decide how to organise the material and report back after 30 min. Their oral report should include their opinion as to who is more at risk (the 4 year-old boy or the 6 year-old girl), their assumptions they have used to make their decision and the advice they would give. The tutor should sit quietly and observe the group interaction and fill in the group mark as per the scheme provided.

Fig. 2. An example of instructions for tutors for a typical Session 4 activity. For this 'information soup' exercise, the tutors were also given a list describing each piece of information and what could be deduced from it, full notes outlining the prior knowledge that should be shown by the students, as well as the answer to the task, and a direction for mark allocation.

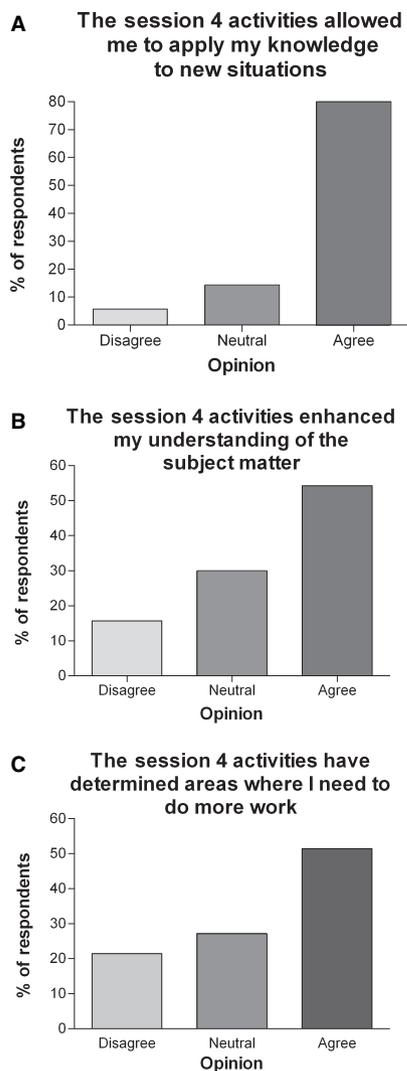


Fig. 3. Evaluation of Session 4 activities as a supplement to PBL. Students were asked to respond to each statement with either 'agree', 'disagree' or 'no opinion'.

Development of transferable skills

These activities were designed to not only allow students to assess their own understanding, but also to develop additional transferable skills that would be of both immediate and long-term benefit to their PBL sessions, other areas of the programme and their future careers. When asked if these activities had helped them to develop problem-solving skills, there was strong concurrence (69%) from the students (Fig. 4A). There was less distinction between those students who agreed and those students who had no opinion on their development of lateral thinking skills (49% and 39% respectively; Fig. 4B).

Although students confirmed that these activities had helped them to strengthen their team working skills (80%; Fig. 5A), it was also important to ascertain how taking part in these activities impacted on future group dynamics. The marks obtained from completing these tasks contributed to the students'

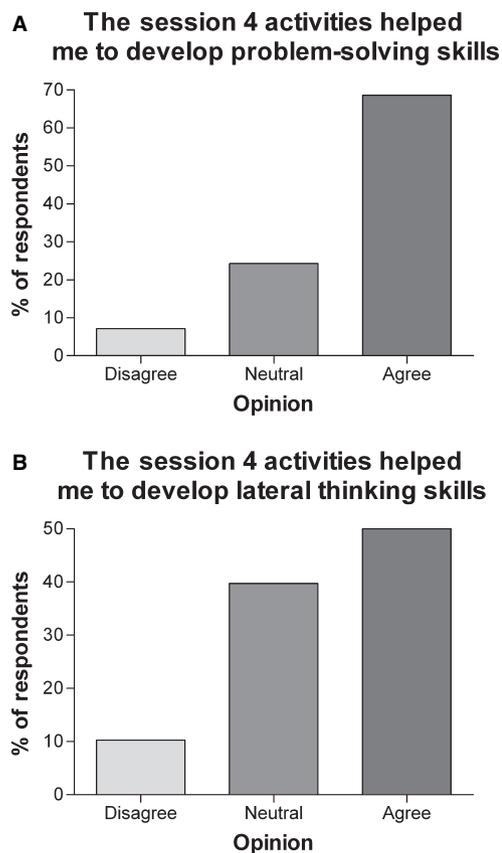


Fig. 4. The development of transferable skills. Student assessment of the role of Session 4 activities in the development of (A) problem-solving skills and (B) lateral thinking skills.

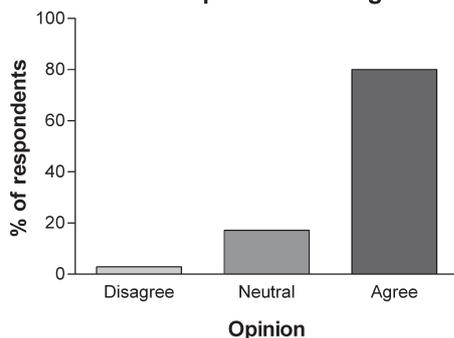
coursework marks, and if individual students failed to contribute adequately to the activity the whole group were marked down accordingly thus affecting the coursework mark of other students. There is potential for this to have a negative consequence on subsequent group sessions. However, the majority of students confirmed that the group dynamics were not adversely affected (86%; Fig. 5B).

Student observations

As described in the Methods, 11 different Session 4 activities were delivered during year 1, which were categorised according to the nature of the activity (Table 1). Note that each category does not contain the same number of activities, e.g. two activities were 'information soup' tasks whereas a single journal club exercise was used. From the Table, it is clear that the students enjoyed some categories of activities over others. For example, the 'information soup' exercises were clearly enjoyed by a number of students, whereas activities requiring data handling were not enjoyed by the students. However, for the other categories, there is less distinction and activities tend to be enjoyed or disliked to a similar extent.

An assessment of the Session 4 activities as a whole revealed an overwhelming majority of students felt that these sessions

A The session 4 activities have helped me develop team working skills



B The session 4 activities had a negative effect on the PBL group dynamics as a whole

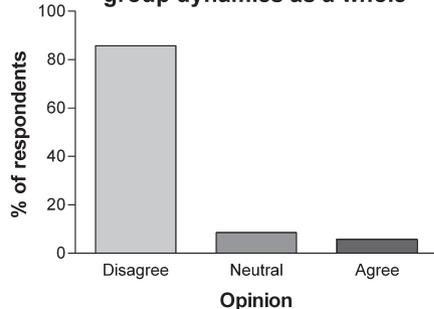


Fig. 5. Evaluation of the effect of Session 4 activities on (A) developing team-working skills and (B) group dynamics.

were generally fun (63%; Fig. 6A) and challenging (83%; Fig. 6B) and by no means a 'waste of time' (76%; Fig. 6C). One student remarked that these activities were 'the best thing about PBL'. Concurrent with these overall observations was the majority view of students to maintain these activities as part of the PBL programme (67%; Fig. 7). A minority of students did wish to replace these activities with alternative sessions, either additional PBL discussion sessions (6%), private study time (13%) or student-led presentations (3%).

When asked how the Session 4 activities could be improved, there was a general fixation by some students on assessment procedures, e.g. one student commented 'the questions should be exam style'. This was confirmed by another student who stated that the questions should be either 'MCQ-related or possibly OSCE-related'. A number of students ($n = 11$) also reported that they wished to take a copy of the answers to the tasks with them at the end of the session 'for revision purposes'.

Staff observations

Following round table discussions with tutors ($n = 10$), it was clear that tutors were very positive about the Session 4 activities. The activities were eagerly anticipated at the end of a PBL case and were seen as innovative and exciting learning resources for the students to work through. Comments included, 'it was refreshing to see students engaging in lively debate during the blunder case'; 'quieter students were actively encouraged to participate by their peers'; 'seeing students logically piece together (and sometimes successfully solve) a problem was genuinely satisfying for both the tutor and the students themselves'; 'there was always an agreeable buzz in the room during Session 4s'. Tutors also appreciated having the opportunity to give direct feedback regarding the students' level of subject knowledge, overall organisational abilities and team-working skills. It was commented that it felt equitable to award group marks for these activities; although the marking scheme as written (on a scale from 0 to 2) made it too tempting to give high marks that were perhaps not fully deserved. All tutors appreciated that the student assessment associated with the activities required no extra work or preparation in addition to the 55 min PBL session, as full notes and marking schemes were provided. However, a few tutors did note that the marking instructions could be made more explicit for some exercises. Some activities were more obviously enjoyed by the students than others (as reported above) but tutors felt that all exercises allowed the practice of different skills, all had use in generating lively discussion and alerting the students to how much (or how little) information they had understood and remembered from their previous self-study. Staff who had been responsible for generating the resource materials ($n = 5$)

TABLE 1. Student evaluation of the different types of activities delivered

Category	Enjoyed the most (no. students) ¹	Least enjoyed (no. students) ¹	Comments
Information 'soup' exercise	22	0	
Blunder EBL	12	2	'If you can pick out the mistakes then you obviously know your stuff'
Drip-feed activities	8	7	'Did not like this task as the diagnosis was something that we hadn't covered'
Journal club	14	6	'Excellent way to introduce us to using journals'
Data handling	5	39	'Disliked because I had to draw a graph'
Happy families	10	11	
Picture quizzes	6	7	

Eleven activities were run over the year and each activity was assigned to a category depending upon the nature of the activity.

¹Some students ticked more than one category.

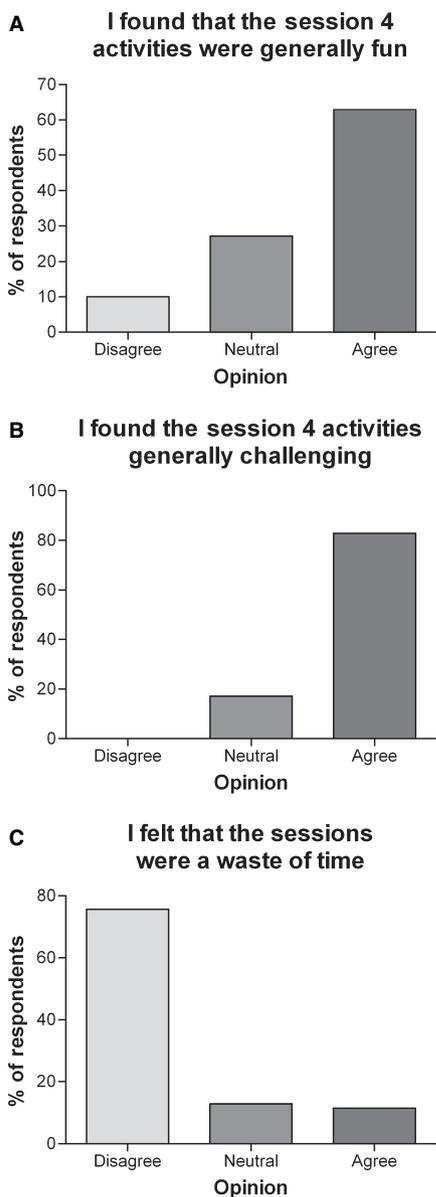


Fig. 6. Student evaluation of Session 4 activities in general.

commented that they had enjoyed the creative challenge in preparing and developing the Session 4s and looked forward to creating new materials in future so a ‘pool’ of resources could be assembled.

Discussion

It has been established that PBL is an enjoyable and motivating method of learning for students (1, 17) and that knowledge acquisition by PBL is on a par with conventional lecture-based courses (18, 19). However, assessment of PBL courses has been criticised for the emphasis placed on content recall rather than process and performance in context (20). PBL itself has not been proven to improve clinical problem-solving or diagnostic reasoning (17, 21). In addition, if students are expected to use

Would you prefer to replace the session 4 with ?

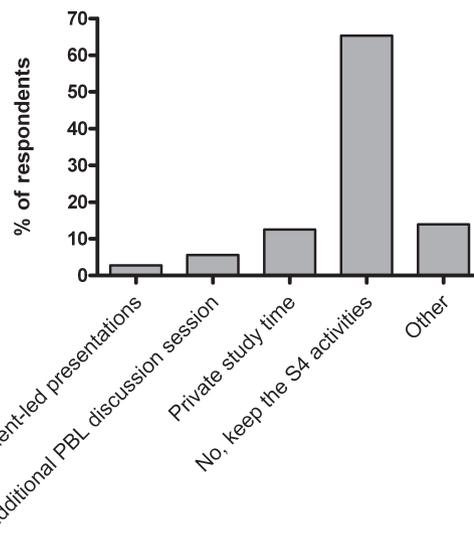


Fig. 7. Maintaining Session 4 activities as part of the PBL programme. Students were asked if they would like the Session 4 activities to continue or to replace the activities with an alternative option.

knowledge to solve problems in the world of work, then it is desirable to provide them with the opportunity to practice such skills and receive feedback on their performance. For all these reasons, a unique fourth PBL session was introduced into TMDP at the end of each 2 week PBL case. We focused on enhancing student ‘co-operative learning’, where individual success is only available when all team members collaborate effectively (22). By augmenting the fun aspect of these sessions, we hoped to provide a productive learning environment as described in the ‘control theory of learning’ (23). Our ‘Session 4s’ allowed a summative assessment of individual achievement and the chance to improve skills such as (clinical) problem-solving, lateral thinking, teamwork and time management. The Session 4s also offered an introduction to the process of diagnostic reasoning, data-handling, accessing scientific research literature and the possibility for individual students to determine their own areas of knowledge weakness. Feedback regarding ability in all these areas was available immediately at the end of the Session 4s. Students were thus provided with suggestions for self-improvement in a timely and appropriate manner, a desirable and recommended feature of feedback (24). The long-term effectiveness of introducing these activities into our dental programme can appropriately be evaluated using longitudinal studies (focus groups with students and clinical tutors, questionnaires) of this student cohort to determine the impact of their transferable skills developments on their professional performance.

Students have preferences for the ways in which they receive information and this can affect their ability to learn in the most effective and efficient manner. Several approaches have been used to categorise these learning preferences or ‘learning styles’ (25, 26), with the most frequently quoted being the VARK system (27). This attributes styles of learning to the major sensory modes of learning (Visual, Aural, Reading/writing and

Kinaesthetic) depending on the neural system with which a learner favours. Students can use all sensory modes, and indeed studies have shown that (medical) students generally adopt a multi-style approach to learning (28) and thus are potentially extremely adaptable in how they deal with information. However, one mode can sometimes be dominant and for this reason a range of activities were developed for the Session 4s in order to accommodate the varying approaches to learning of different students.

The activities were deliberately developed to encompass the principles of 'active learning', which has been defined as 'the process of having students engage in some activity that forces them to reflect upon ideas and how they are using their ideas' (29). As Chickering and Gamson (30) observed, 'learning is not a spectator sport', accordingly active learning is widely acknowledged as good practice for undergraduate education (29, 31). In other Higher Education Institutions, 'blunder lectures', where students have to identify deliberate mistakes included during the course of a lecture, have been used successfully to support teaching and learning for physiology subjects (32). This idea was developed in our Faculty into the 'blunder case' exercises. Other activities for TMDP were designed here as unique exercises and all required skills including image recognition ('visual' processing), group discussion ('aural'), scientific reading and critique (reading), graph drawing ('kinaesthetic') as well as demanding knowledge recall, subject understanding and rewarding a logical approach to problems.

It was found to be worthwhile developing a number of diverse activities for TMDP as every type of exercise was voted as the most enjoyable by at least five students, and nearly all (with the exception of 'information soup' exercises) being voted the least liked by others. The student response to the Session 4 activities overall has been extremely positive, with the majority finding them fun, yet challenging, and 'worthwhile'. Other studies have shown similar positive student responses to educational games and activities intended to enhance learning (33–38). For the Session 4 activities here, the majority of students perceived them to enhance subject understanding, develop problem-solving abilities, allow the application of knowledge to new situations, and help to identify gaps in knowledge where further study could be directed. Whether these perceptions were actually true and whether they could solely be explained by the introduction of Session 4 activities is hard to assess. The whole dental course was revised for the year starting in September 2006, and thus other aspects of the course were revamped and delivered in new ways as well, making an evaluation of the impact of the Session 4s in isolation impossible.

The marks awarded for the activities contributed to the coursework mark for the year, thus providing an incentive for those students motivated purely by assessment to partake fully in the sessions. One student did comment that they would have preferred 'possibly a personal score (on effort) as well as a group score', although staff felt that individual effort was rewarded enough in other traditional assessments in the course and this was one of the few occasions that group marks could be fairly awarded. In response to tutor demands, the marking scheme has now been revised with the five criteria for marking reduced to four ('initial approach to the task' is now combined

with organisation of group/time management; equal participation of all individuals; utilisation of acquired knowledge; quality of task completed) and the number of marks to be awarded changed to be on a scale from 0 to 3, with 3 being excellent; 2 good; 1 satisfactory and 0 poor. This is in the hope of restricting the highest mark for excellent students only. In addition, guidelines for allocation of marks for completion of the task were made more explicit. The Session 4 activities were extended to year 2 topics from September 2007. These topics included mechanics of ventilation; blood and anaemia; pharmacy of asthma; periodontitis; chest pain; immunology; pain; calcium homeostasis; stroke and neurology.

Conclusions

As warned by Colliver and Markwell (39), studies that report student perceptions of educational value must not be falsely attributed as showing 'proof' of educational effectiveness, and thus we make no such claims here. However, the introduction of an innovative PBL Session 4 into TMDP can be judged a success for staff and students alike by several measures. The sessions provide a means to award a summative assessment of performance that does not just rely on content recall, but on knowledge application in alternative scenarios. They allow skills such as teamwork, problem-solving and lateral thinking to be recognised and rewarded for the useful skills they are. The sessions allow students to get immediate feedback on such skills and to have a chance to improve over the course. The students can identify topic areas that they may have missed, or have misunderstood, and thus obtain direct guidance for their self-study. The logical approach to clinical diagnosis is also assessed, something that has not been adequately addressed in other PBL courses. The Session 4s allowed students to engage with learning and assessment in a fun and relaxed, yet productive, environment, such that the majority of students were happy for the Session 4s to be continued in the same format in future. It must not be overlooked that staff looked forward to these Sessions too, and found them a genuinely innovative and creative way to assess student understanding and skills development in a PBL course. In Manchester, we use these Session 4 activities as an assessment team-exercise to augment PBL for dental students. Some activities have been adapted for use in our lecture-based degree programmes, e.g. use of a drip-feed activity for pharmacology students to assess their understanding of lecture material content. This example highlights how these and similar activities can be readily adapted for use in any other subject area, to enhance student's revision, knowledge integration and consolidation.

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