Using Problem-Based Learning In Neurosciences Education for Medical Students

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ABSTRACT: ***Background:*** A Curriculum Task Force proposed problem-based learning as one important educational strategy and recommended changes to a traditional medical curriculum. ***Methods:*** This paper describes how a problem-based learning course in neurosciences was developed and has evolved since its inception in the Dalhousie University Faculty of Medicine. The curriculum planning and design phases are outlined, followed by a description of how the course has been implemented and evaluated. ***Results:*** Program evaluation results are presented, describing student performance on examinations and their feedback about the course. ***Conclusion:*** The authors summarize lessons learned and identify future issues to continue the ongoing development of the course.

RÉSUMÉ: Apprentissage par problème dans l'enseignement des sciences neurologiques aux étudiants en médecine. ***Introduction:*** Un groupe de travail sur le curriculum a indiqué que l'apprentissage par problème est une stratégie d'enseignement importante et a recommandé des changements au curriculum médical traditionnel. ***Méthodes:*** Cet article décrit le développement et l'évolution d'un cours de sciences neurologiques basé sur l'apprentissage par problème, depuis son instauration à la faculté de médecine de l'Université Dalhousie. Nous donnons un aperçu des phases de conception et de planification du curriculum et nous décrivons comment le cours a été établi et évalué. ***Résultats:*** Nous présentons les résultats de l'évaluation du programme et nous décrivons la performance des étudiants aux examens et leurs impressions sur le cours. ***Conclusion:*** Les auteurs font un sommaire des leçons apprises et identifient les enjeux importants pour le développement du cours dans l'avenir.

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Many medical schools have adopted problem-based learning (PBL) as their primary method of undergraduate medical education.[1-4] Others have implemented PBL as a parallel track for some students,[5,6] and some have introduced limited PBL experiences into a traditional curriculum.[7] Although much has been written about PBL curricula there are few descriptions of how a PBL course in the neurosciences has been developed, implemented and evaluated.

PBL has been defined as "... the learning which results from the process of working towards the understanding of, or resolution of, a problem".[8] Students first encounter a problem in a clinical context and discuss the problem in tutorial groups, assisted by a faculty tutor, and identify learning issues for further study. Students return to the group to apply their newly acquired learning to the problem. The purpose of the problem is primarily to stimulate an understanding of the basic science mechanisms involved, and secondly, to arrive at a better understanding of the clinical problem.

The most frequently cited rationale for PBL is based on three principles from learning theory:[9,10] 1) knowledge learned in a context similar to one in which it will be used will be more readily retained and applied in the future; 2) knowledge which is elaborated by students, i.e., debated, discussed, and applied from many points of view, will be more readily understood, retained and transferred; and 3) knowledge which builds on the experience of students will be more readily integrated into their cognitive structure, i.e., better retained in memory. Based on these principles and the results of a curriculum task force on undergraduate education in the faculty, a new curriculum was developed. It became known as the "COPS" (case-oriented, problem-stimulated) curriculum. This paper describes, in detail, the development of a PBL course which integrates neuroanatomy, neurophysiology, psychiatry, and some neuropharmacology. In this context, we have created the building blocks for medical student learning in clinical neurosciences which continues in Years 3 and 4 of the curriculum. We also describe the implementation of the course over four years and some evaluation results to support our conclusions.

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METHODS

The overall design, planning and governance of the curriculum resides with the COPS Curriculum Committee, comprising basic scientists, clinicians, educational staff, and students. The Committee appoints faculty to be unit heads and assigns them the responsibility to prepare comprehensive courses called "units".

Learning neuroanatomy, neurophysiology, psychiatry, and some neuropharmacology at Dalhousie was assigned to a ten-week unit in the curriculum called the Brain & Behaviour unit. It was recognized that an important task was to integrate all of these components and present them in the context of "real life" clinical cases. A unit committee developed a list of objectives. This was an interactive process which brought together the "ideals" of all topics that should be covered, the content of the traditional curriculum, and adapted it, recognizing the reality of a ten-week unit. Ten clinical case scenarios were identified, one for each week, and the objectives and specific learning activities were created around them. These cases were chosen and introduced to students to represent learning neurosciences beginning with the peripheral and concluding with the central nervous system. Writers for each case represented faculty from several basic science and clinical disciplines including neurology, neurosurgery and psychiatry, thus ensuring not only better integration, but a realistic clinical context for learning.

Several standard textbooks were recommended for the unit, and additional references were suggested. An end-of-unit written examination was designed with guidelines developed by the COPS Curriculum Committee. A mid-unit learning examination for feedback purposes only was instituted.

The unit was planned as the first unit in second year, followed by units in Skin, Glands & Blood (eight weeks), Respiratory & Cardiovascular (eight weeks), and Genitourinary, Gastrointestinal & Musculoskeletal (eight weeks). Units which were also in the second year, but occurred only once per week, were Clinical Epidemiology & Biostatistics, Patient-Doctor and Electives. In the third and fourth years, students participate in clinical clerkships as well as weekly didactic sessions including clinical neurosciences.

Structure and function of the Brain & Behaviour unit

Students were randomly assigned to tutorial groups of seven or eight, with a faculty member appointed as a tutor. Groups ran concurrently and worked through the same cases, which formed the backbone of all units in the first two years. Laboratory experiences, clinical demonstrations and lectures complemented the cases. In this way we've introduced a variety of learning formats for our students and provided opportunities to address learning objectives that would not naturally arise in the cases.

The tutorial groups completed one case per week. The learning objectives for a typical week emphasized understanding of basic neuroanatomy and neurophysiology. Additional objectives were also included so students would understand the clinical features of the case important to the basic science objectives and the behavioural objectives relevant to psychiatry. A primary motivation for students was developing an understanding of the patient's neurological condition, through the use of basic science concepts necessary for a clinical reasoning process. In this way students learned their basic science in a clinical context around cases.

One noteworthy aspect of the tutorial group process was that the tutor was not necessarily an expert in the content covered in the case. For this, students had access to expert resource faculty assigned by the unit committee. The tutor was responsible for many tasks such as guiding students through the clinical reasoning process, helping them identify learning issues, and asking appropriate questions to assist learning. The tutor also was responsible for evaluating the tutorial performance of each student in the group with regard to the use of the reasoning process, acquisition and integration of knowledge, cooperative learning, interpersonal skills, and self-assessment skills. Students had to pass the tutorial evaluation, as well as the end-of-unit examination. In order to foster a climate of cooperative learning, and to develop the "team" skills which students would require in their careers, a pass/fail grading system was adopted by the COPS Curriculum Committee.

A typical week in the unit

As students in a tutorial session worked through each case with the help of their tutor, they identified questions, or "learning issues"; these were assigned to individuals or the group and discussed at the next tutorial. In order to allow students time to pursue their learning issues, and to develop skills in self-directed learning, their weekly schedule was structured to provide a balance of structured and self-directed learning.

Cases were written to be covered within three sessions of two hours each within one week. Each page of a case contained new details of the clinical case. Students were encouraged to identify "learning issues" based on their own discussions and generate hypotheses about the case. Students were given one page of the case at a time and new pages and new information are provided as the case "unfolds".

Over the ten weeks of the unit, ten cases were used, each to serve as the focal point of all the week's activities (Table 1).

Over the ten weeks of the unit, 3-5 lectures/week were given. The lectures were linked to the subject material of the case but did not undermine the concept of self-directed PBL. They served to either introduce broad subject areas, or particularly complex material not adequately discussed in reference sources.

The unit's lab experiences were neuroanatomy and neurophysiology held weekly, and clinical demonstrations were done with a neurologist and the full class. This allowed for "hands-on" exploration of the common themes throughout the cases.

Faculty recruitment

Faculty were asked to volunteer to tutor in any unit of their choice with a preference given to returning tutors to be reassigned to the same unit. Recruitment was carried out by the Division of Medical Education. Every attempt was made to recruit both clinicians and basic scientists, and to encourage faculty to volunteer in units outside of their disciplines. In addition, we had concerns that PBL tutors who are experts would tend to be too directive, or present information, rather than assuming a more facilitative role.[11,12] Recruiting tutors necessitated a flexible approach to accommodate their other commitments such as clinical service and research.

Because the Brain & Behaviour unit was one of our longest (10 weeks), we promoted a concept of team-tutoring so that two faculty members could each share the commitment by tutoring either the first or second half of the unit.[13] The Faculty of

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Table 1: Major Topics in Brain & Behaviour Cases.

Case No.	Titles & Major Topics
1	*The Disappearing Weakness* Myasthenic Syndrome, Synapses, Neural Communication
2	*The Teenager Who Could Not Stop Washing* Obsessive Compulsive Disorder, Tic Disorders, Serotonergic Dysfunction
3	*The Lady Who Had to Watch Her Feet to Walk* Subacute Combined Degeneration, Reflex Arcs, Spinal Cord, UMN vs. LMN
4	*Brian Stokes, The Dizzy Steeplejack* Lateral Medullary Syndrome, Brain Stem, Cerebral Circulation
5	*The Red Herring Case* Mood Disorders
6	*The Case of the Deaf Housewife* Acoustic Neuroma, Auditory System, Vestibular System, Cerebellum
7	*Failing in School* Schizophrenia, Biologic Factors of Psychiatric Disease
8	*The Case of the Reluctant Golfer* Parkinson's Disease, Basal Ganglia
9	*Mrs. McSween's Disco Lights* Epilepsy, Visual System
10	*Madame Auguste* Dementia, Cortical Function, Neurodegeneration

Medicine has adopted a resource allocation model whereby tutoring in the curriculum has a substantial effect on the educational component of department budgets.[14] The result has been favourable from a recruiting point of view as each department has an expectation to provide tutors for the curriculum. Because students in the first year of the curriculum met our expectations in becoming proficient with the reasoning process in the tutorials, we introduced a concept of "tutorless tutorials" in which tutors would be present for only two of the three tutorials in a week in second year units. The third tutorial would be run by the students themselves. Our feedback from students and tutors alike has been that the tutorless tutorials have been accepted as satisfactory. We felt our approach to recruiting tutors would address our concerns and have the desired effect of fostering cross-disciplinary teaching opportunities for our faculty. This proved to be particularly effective in the Brain & Behaviour unit.

Faculty development

Several different approaches to faculty development for PBL have been reported in the literature.[15-17] At Dalhousie, we designed a seven-stage faculty development process which has been described in detail elsewhere.[13,18] The stages are: orientation workshop, unit orientation meeting, weekly tutor meeting, tutorial observation, unit evaluation, tutor evaluation, and continuing education.

The unit orientation and weekly tutor meetings were critical to the success of this unit, and to the quality of the tutors' experience in this unit. A standardized agenda for the unit orientation meeting of all units was prepared in the Office of Undergraduate Medical Education and Student Affairs which was then modified to suit the Brain & Behaviour unit. The unit orientation meeting introduced the overall unit, especially the schedule of all the learning activities over the ten-week period. Many of the administrative procedures, such as completing evaluation of student reports, were discussed. The first case was discussed in detail and the tutor guide was referred to so there would be a consistent approach to the pacing of the case during the week. During the weekly tutor meetings, tutors discussed the case just completed that week and provided not only their feedback to the unit head but also a summary of the student feedback collected from each tutorial group on a standardized form. This was an integral part of our process for monitoring student progress and gathering input for case revisions. It also served to prepare tutors for the case about to begin the next week. We also felt that tutors from a variety of disciplines could be able to use this venue as an informal faculty development opportunity where they could discuss their experience with fellow tutors in a timely manner and in the context of a specific case. New tutors would presumably benefit from the savvy tips of experienced tutors.

Each new tutor is observed once during the unit by a peer tutor. The observer sat through an entire two-hour tutorial, and then provided feedback to tutors and their tutorial group. This is done in an informal and non-threatening manner. In particular, this activity helps boost faculty confidence that they are "on the right track".

The unit evaluation stage is a final meeting of tutors and unit planners held at the conclusion of the unit. This meeting reviews student performance, assesses the cases and other unit components, and generates recommendations for improvement. Several weeks after the unit ends, all tutors received a summary of the results from an end-of-unit questionnaire completed by students to evaluate them. A summary of results for the complete class also was provided, so that faculty could compare their individual ratings and comments with the overall results. The final stage of the faculty development process, continuing education, is ongoing.

Results

Program evaluation

Although our formal program evaluation of all the units in the curriculum is conducted at the end of each unit, we collected information about the cases, other learning activities during the week and student progress at the weekly tutor meetings. In planning for the 1997/98 academic year, the Brain & Behaviour Unit Committee reviewed the student evaluations from the previous year. Generally, the student evaluations were positive and regarded more highly than the mean of all units in second year. A common theme of feedback from students, both formally and through the tutors at the weekly tutor meetings, was that psychiatry needed to be organized differently. Many students felt that scheduling the cases that emphasized psychiatry learning issues as a three-week block at the end of the unit results in an artificial separation of psychiatry from the rest of the neurosciences teaching. As well, students expressed concern that they were not able to focus on psychiatry adequately, as it was being presented during the lead-up to the final examination. This has been a recurring theme in feedback to the unit for a few years. Members of the Department of Psychiatry have also noted this problem and were interested in change.

The psychiatry component of the unit was integrated into the main body of the unit instead of being scheduled in the final three weeks and were introduced during weeks two, five and seven.

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The psychiatry lectures and clinical demonstrations corresponded with the cases. In addition, two new cases were introduced to the 1997 unit. As well, a third case was extensively revised. These case changes were undertaken to provide a broader coverage of unit objectives and clarify some confusing aspects of prior cases.

The unit feedback was quite good (Table 2). The students commented that it was interesting material and clinically relevant. Students felt that some lectures needed improvement. The most noteworthy difference in comparing evaluations from 1996/97 to 1997/98, was the amount of time reported in independent study. An average decrease of seven hours per week might be partially explained by the objectives being more explicit and a perception by this class that the subject matter was not as difficult as that reported in the previous years.

Once again, a common theme in the 1997 Brain & Behaviour unit feedback was a request for changes in the psychiatry component of the unit. Several students pointed out that the psychiatry objectives were in need of improvement. This has been previously noted and the psychiatry case changed for 1997 was partly in response to that concern. The 1998 psychiatry cases will need to be altered to improve objectives. Many students felt that the integration of psychiatry into the rest of the unit did not yet work well. Many students felt that the relevant neuroanatomy and neurophysiology was only learned after the psychiatry cases were completed. The students felt uncomfortable with the switching back and forth between psychiatry and the other neuroscience disciplines.

Student feedback to the examination was very favourable. The majority of students who made a comment on the fairness of the examination felt it was quite fair. The students liked the short answer question format and appreciated the learning examination reflecting the format of the final examination.

Student performance

A take-home mid-unit learning examination was provided to the students which matched the format of the final examination. The students were provided with model answers for the mid-unit learning examination questions.

The end-of-unit examination consisted of a one-hour laboratory examination, evaluating neuroanatomy knowledge and a three-hour written examination which evaluated neuroanatomy, neurophysiology, and psychiatry knowledge from all learning formats in the unit. The final mark for the unit was a composite mark for all aspects of the final examination. The content of the final examination was distributed approximately: neuroanatomy 35%; neurophysiology 35%; psychiatry 30% and described to students prior to the exam. The final written examination was case-based with short answer questions evaluating basic science and psychiatry concepts.

In order to satisfactorily pass the unit, the student had to receive a "pass" evaluation by his or her tutor, as well as satisfactorily pass the end-of-unit examination. A passing score for the exam was set at 60%.

All 87 students who attempted the examination in 1997 passed. The class mean was 84.8%. The class median score was 84.9%, which is a bit higher than the 1996 examination which was 78.9%. Although students spend less time in independent study the class mean increased in 1997. We suspect that the student perception of the unit's subject matter as being difficult to understand and their opinion about the workload being considered being more favourable may have contributed to this finding. The median grade for the unit examination has traditionally been quite high.

Obviously an important measure of the students' learning will be their retention of this material and its application in later years

Table 2: Brain & Behaviour Unit Evaluation Summary.*

	Mean Scores 1996/97		1997/98
	Brain & Behaviour Unit (n = 76/82)	All Other Units Med 2	Brain & Behaviour Unit (n = 78/88)
General impression of the unit:			
The unit's objectives were clear to me.	3.63	3.70	3.73
The unit's subject matter was difficult to understand.	3.25	2.75	2.96
The unit was well organized.	3.28	3.22	3.17
The workload in this unit was too heavy.	2.93	2.77	2.86
The cases were clearly presented.	3.67	3.51	3.58
The cases helped me in integrating the basic with the clinical sciences.	4.20	3.84	3.97
Tutorials, lectures, and labs:			
The tutorials have been a productive learning time.	4.09	3.55	3.86
The lectures were integrated well into the unit.	3.39	3.25	3.13
The labs were integrated well into the unit.	4.13	2.29	3.86
End-of-unit evaluation:			
The end-of-unit examination was a fair reflection of the unit requirements.	3.62	3.40	3.71
Open Questions:			
How much time on average did you spend each week on independent study? (Hours)	21.66	21.74	15.77
If you had to rate this unit on a scale from 1-10 (6 = adequate), what rating would you assign?	7.42	6.49	7.37

* Rating scale: 1 = strongly disagree; 2 = disagree; 3 = undecided; 4 = agree; 5 = strongly agree.

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of medical school, postgraduate training and clinical practice. Their performance in standardized licensure examinations and their future practice patterns may ultimately help in this assessment.

Discussion

As this paper has described, neurosciences can be organized successfully in a PBL format. This experience has taught us several important lessons, described below in order to assist others considering a similar approach.

Unit philosophy

This unit was designed to replicate the thinking process used by clinicians in localizing lesions within the nervous system. Traditionally, neurologists are taught to find the lesion(s) before defining the etiology. This is usually taught as a central to peripheral model or vice versa, in that one would first determine if the lesion(s) are at the hemispheric, brainstem, spinal cord, motor or sensory roots, peripheral nerves, neuromuscular junction, or muscle levels. The cases in our unit were organized to introduce neuroscience concepts beginning in the peripheral nerves and graduating to the central nervous system. In this way, we felt students were able to systematically organize their learning from a clinical point-of-view.

Unit organization

As this unit contained multiple activities such as tutorials, lectures, laboratories and clinical correlation sessions, the integration of these activities was key. The cases played the central role for organizing the course. The other activities complemented and reinforced important objectives during the week. Those objectives not arising in a case were elaborated upon elsewhere.

While the cases play a central role in organizing the unit, tutorials are not the only educational activity in the curriculum. Lectures still play an important role in helping to introduce or review critical concepts or explain particularly different or new ones. Lectures serve to motivate the students to pursue the material further by stimulating them with interesting topics and examples and challenging them with questions. Laboratory sessions, clinical correlation sessions and computer assisted learning can all be integrated to provide the students with a wide choice of learning resources to help them master the units concepts and content. Relatively easy access to these materials should be provided.

Case preparation

Cases should be based upon previously delineated objectives. In this unit, they were adapted from the neurosciences teaching in our traditional curriculum. A primary author should be responsible for each case but input from a variety of individuals (both basic scientists and clinicians) is essential. When cases are written collaboratively, there should be sufficient lead time to allow for the participant's busy schedules. Guiding questions for the students can be used if they were included in a detailed tutor guide to help tutors foster student learning issues.

Faculty recruitment, development and support

Recruiting for this unit was not particularly easy. It was one of the longest units and many faculty had other commitments. Multiple strategies were employed to successfully recruit tutors. The Resource Allocation Model of determining the educational component of departmental budgets was particularly helpful.

With regard to faculty development, we learned that proper preparation of faculty is important, both in the area of tutoring techniques and the content of the cases. Since our tutors are not experts in the field, it is essential to provide them with a useful tutor guide for each case. However, it is even more important to provide a smaller number of experts to serve as resource experts for students. Some of these faculty, and particularly the unit head, must be readily available to students during the whole unit. Other complementary roles for faculty in the unit may include case writer, lecturer, clinical session leader, and laboratory instructor.

The myriad of administrative details involved in planning, developing, implementing and evaluating a PBL unit is too numerous and time consuming to be handled solely by faculty. There must be a recognition of, and budget for, resources to support these tasks. Examples include: scheduling, room bookings, faculty recruitment, registration of faculty for workshops, producing cases and exhibits (which support cases), administering and analysing evaluation questionnaires, and setting up software in the computer lab. At Dalhousie, we have an administrative staff in our office of Undergraduate Medical Education and Student Affairs to support our curriculum.

Planning for next year

Data from the program evaluations tell us that this unit has been successful. For 1998, the Unit Committee will need to undertake some further revision of the psychiatry integration. It was felt by the Unit Committee that we should continue to attempt this integration and try to present it in a manner that will seem both logical and helpful for the students. One of the important points made by the students and the Unit Committee members is that an understanding of the basal ganglia is crucial to understanding many of the basic neuroscience concepts of psychiatric disease. An important alteration for 1998 will be to place the basal ganglia a week prior to any of the psychiatry cases.

Revision to the psychiatry cases will hopefully make the integration of the psychiatry component of the unit more seamless with other aspects of the unit. An important goal by the psychiatry component of the unit will be to revise the cases to accurately reflect the psychiatric concepts they wish to convey.

Students' performance has been excellent and they have viewed the unit as stimulating and enjoyable. Faculty involved as tutors or resource experts also have been delighted with their experience, and many have used their involvement in the course as a way of updating their own knowledge of neurosciences. We could hope that the lessons learned at Dalhousie Medical School can serve as a model for others developing PBL courses in the neurosciences.

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