Using Problem-Based Learning to Develop Independent Learners

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Problem-Based Learning Process

Reasons for PBL

1. An opportunity to learn independently and focus on areas that most interest you.
2. An opportunity to practice looking at a problem in the area and quickly pick out the important issues that need to be considered or that you need to learn more about.
3. You will learn to find information in this area to answer any question even if you previously knew nothing about it.
4. You will gain some experience in using a group to help you learn.
5. Being an active learner is more fun.
6. You will experience the teaching method as a student, so that you can evaluate it for yourself, and decide whether to adapt it for your own teaching.

Procedure for PBL

First Class

1. Read.
   - You are given a problem as a prompt for learning.
   - Read and think through the problem. Determine what you want to know more about.
2. Issues
   - As a class, we will generate a list of the issues that need further study.
   - ***Issues* are concepts from the problem which you need to know more about, or to consider further in order to understand the situation described in the problem.**
   - Decide which issues you would like to research for the following class. We will take care to formulate these as **questions** to be investigated. This is your opportunity to direct your studies into the areas which most interest you.
   - As a group, we may decide that one issue is central enough that we will all do some work on the question.

Between Classes

1. Research
   - On your own, research the questions you have agreed to pursue.
   - Summarize, in writing, what you learned through your research (approximately two pages). Be sure to include references so that others can follow in your tracks. Include some synthesis and analysis in your summary. Post to the Learning Management System, for others to read before class.

Second Class

1. Discussion
   - The objective of the discussion is to share your findings and build on the findings of others - **synthesizing** information and reaching a level of understanding higher than possible alone.
   - Share and discuss (not report) the research findings as a group.
   - **No one should speak for more than five minutes**; ask a question or build on ideas expressed.
   - **Everyone** should aim to ask questions, make connections, and ensure equal contributions from all participants.
2. Summary
   - We will be **aware** of, and **identify,** the important things we have learned.
3. Feedback
   - Review of the process and our performance to ensure that the next round is as good or better!

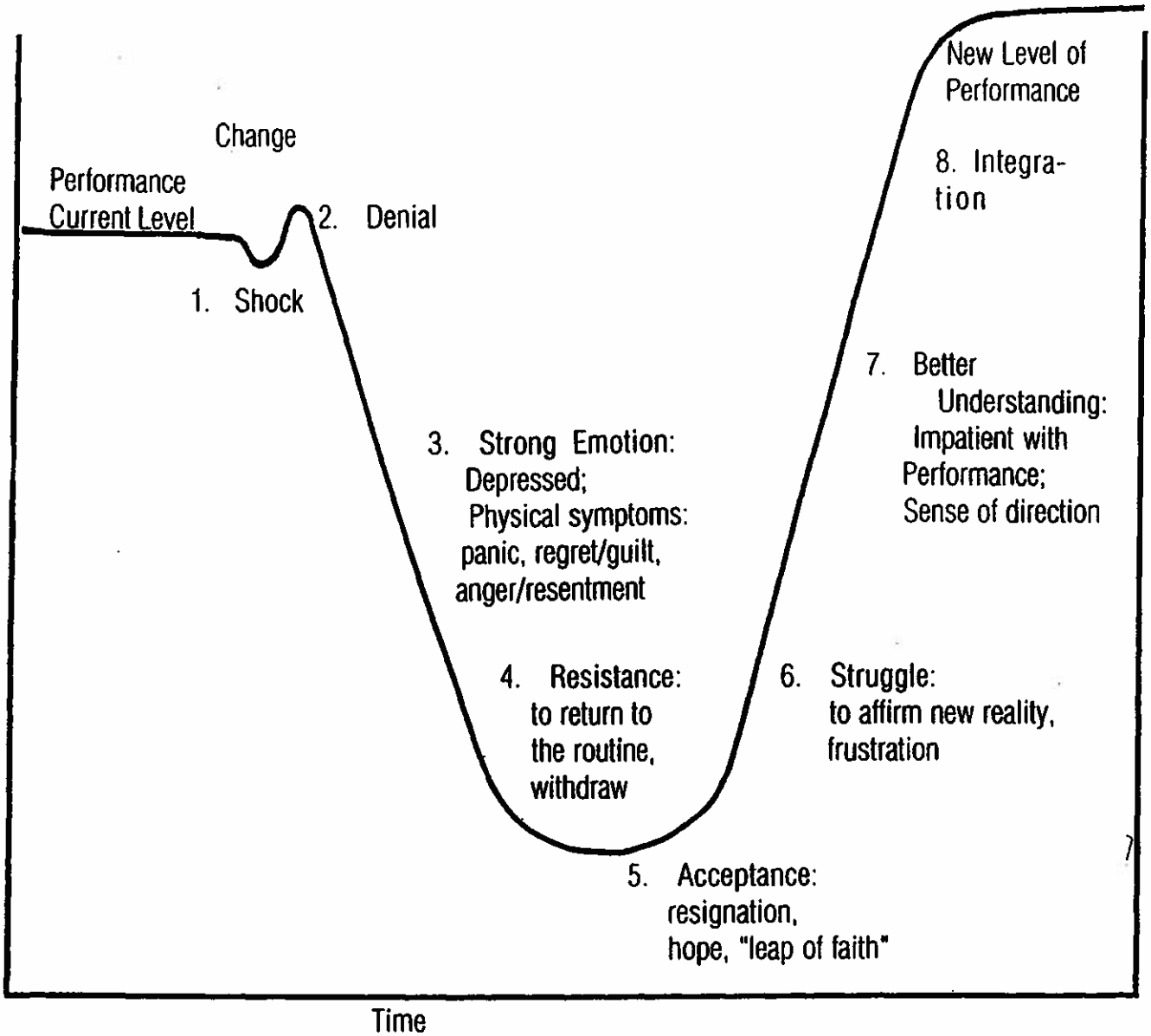

Figure 1-1 The *grieving* process as a model of how we cope with change

The Role of the Tutor

Hugh Pross (2003). Queen's University MD Program Pase II: Problem-Based Learning Student/Tutor http://meds.queensu.ca/pbl/assets/pblhndbk2009.pdf

The tutor is a university educator who leads a task-oriented group to successfully achieve the objectives of a teaching programme. In doing this the tutor has to fulfill several responsibilities and is accountable to the teaching programme for the satisfactory completion of them. These responsibilities require abilities and skills relevant to the principles and practice of problem-based learning, group dynamics, the assessment of student learning, the use of learning resources and managerial skills.

The role of the tutor is very different from the usual teacher's role. Rather than being a "content expert" who provides the facts, the tutor is a facilitator, responsible for guiding students to identify the key issues in each case and to find ways to learn those areas in appropriate breadth and depth.

Although students have much more responsibility in PBL than in most conventional approaches to teaching, the tutor is not just a passive observer. He or she must be active and directive about the learning process to assure that the group stays on target and makes reasonable choices on what issues are key to study. Faculty members also have considerable influence on what is learned by selecting the problems in the first place and by creating tutor guides and specific objectives for each phase of the curriculum.

QUESTIONS TUTORS MAY ASK

Appropriate questioning is one of the most important means of facilitating learning. It can serve to keep the group focused and prevent it getting bogged down. It also can help group members by forcing them to present information and concepts more precisely. Knowing how and when to ask appropriate questions is one of the principle skills of a good tutor.

Questions may elicit a students' reasoning process. If a student asks for more information about the case (e.g. "Did the patient vomit?"), the tutor might ask "What are you hoping to find out? What are your reasons for asking that question? How would knowing the answer make a difference in your understanding of the patient's problem?

• Putting this particular situation aside, **what is the core information** you will need to know for future similar situations (ie. five years down the road in your own practice?)
• Is there anything about this situation that presents **a learning issue outside of this problem**?
• The tutor encourages students to **make connections**. The tutor might ask, "What is the association between hypertension and headaches? How might issues about patient lifestyle be related to this problem?

• Tutors **emphasize open-ended questions to promote discussion** rather than focusing on yes/no type questions or using quiz type questions.
• **Questions can direct students** along another path: Assume this is the situation ..., what do you need to know?
• Tutors must learn to **tolerate silence.** When communication stops or is at a standstill, wait thirty seconds, someone is bound to talk. It may help to ask the group why they are stuck or to ask someone to summarize.

• Tutors should **emphasize mechanisms and causes** of patients' problems. The tutor might ask, "What processes could have caused this problem? What are the mechanisms involved here?"
• Tutors should periodically ask students to **explain and define medical terminology used.** The tutor might ask, "What is cholesterol? What does that level of cholesterol usually mean?"

• Tutors should ask **higher order questions.** For example, in discussions of treatment it is more helpful to ask "How do we decide what to do?" than "What is the best treatment?"
• Other examples of helpful questions are:
Why do we treat this condition? What is the mechanism of action of this drug?
What is the evidence that treatment makes any difference? How do you decide which lab tests to do?

OTHER HELPFUL HINTS
• Do not be afraid to join the group as a participant.
• Do not dominate the group with your opinions but rather facilitate the group dynamics.
• Remind students of topics previously discussed but not fully understood.
• Focus the group by introducing terms to describe what the discussion is about (e.g. body image). Even better, help the students label the general principles themselves.
• Before considering any intervention, ask yourself, "Will my comments help the students to learn how to learn?"
• Encourage the students to focus their discussion, rather than going off in all directions at once. It may be helpful to get the group to construct "diagnostic grids" or "concept maps" (see above).
• Periodically remind students about how much they are learning. Be specific and give examples.

Sample Timing for PBL Discussion

(Second Class)

1:30 – 1:10	**1. Arrival and Loose Ends (10 mins)** • Address any issues that have come up since the previous class
1:10 – 2:10	**2. Discussion of learning in Case (~60 min)** • Write questions you would like to be asked on the board as you arrive (this helps guide people) • **Reminder**: Jot down any point you find interesting during the discussion and would like to remember • Start a general discussion on the PBL case – it helps to begin with an overall question that everyone has researched • Bring in specific research when and where appropriate • Synthesize, analyze, integrate, question, reflect on how you might use the ideas • So What? What does this all mean (Note: as a facilitator, you can ask questions, and help manage group dynamics, but be careful not to become the 'expert' who lectures)
2:10 – 2:25	**3. Anything that you have not yet had a chance to mention (~15 min)** • Any questions on the board you would like to mention? Or • Go around in a circle so everyone has an equal chance
2:25 – 2:30	**4. Summarize learning (~5 min)** • What practical conclusions can we draw from this discussion • What can you now say that you couldn't last week? • What were the most interesting/surprising/important points? • What are you taking away from the discussion today? • What were they key concepts that came up in the discussion?
	5. Share written materials
2:30 -2:45	**Break (15 min)**
2:45 – 3:00	**6. Debrief the process (~15 min)** • Gut Reactions – How did you feel? • What made any particular question a good one for our purposes? • What research strategy did you use and to what effect? • What makes for a good written report? • What makes for a good discussion of the case? • **How did this group function?** • Is this process working for us? • Agree on changes for the next case
3:00 – 3:25	**7. Issues (~ 25 min)** a) For the short cycle, you would now get a new problem, and generate issues b) For the long cycle, you would look back at the original problem and ask: • What do I still need to know? • What are the gaps?
3:25 – 3:30	**8. Preparation For next week (5 min)** • Choose questions to research for the next week. • Remind the group of any changes to the process that were agreed upon during the Debrief process.

Possible Reflection Questions following PBL

Content
What were the key points mentioned in the discussion?
What were the key content points you learned?
What surprised you?
What practical conclusions can we draw from this discussion?
What can you say now that you couldn't last week?
What were the most interesting/surprising/important points?
What are you taking away from the discussion today?
Do you understand the situation in the case better now?

Process
What was difficult in the process?
How did you feel?
What was your gut reaction to the process?
What strategies worked that might help others?
How would you change the process?
What made any particular question a good one for our purposes?
What research strategy did you use and to what effect?
What makes for a good written report? What is helpful to other people?
What makes for a good discussion of the case?
Is this process working for us?
What changes should we make for the next case?

Contributions and Dynamics
How did this group function?
What were your own strengths and weaknesses?
What should each group member
- continue doing?
- change to improve for next time?

Key Discussion Points

An optional tool that can help guide students to identify critical points raised during the discussion

Concept/Idea	*Details/Description*	*How does it relate to the Problem?*

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FEEDBACK GRID

Continue… *Comment on aspects of performance that were effective. Be specific and describe impact. Highlight things you would like to see be done in the future*	**Start, or do more….** *Identify behaviour the student knows how to do, and could do, or do more often*
Consider… *Highlight a point of growth for the learner, a "doable" challenge for future interactions*	**Stop, or do less** *Point out actions that were not helpful, or could be harmful. Be specific, and indicate potential impact*

(Modified from the Coaching Feedback Format, Bayer Institute for Health Care Communication) A. Walsh: **Delivering Effective Feedback**

Peer Feedback on Group Tasks

Name: _____ **Date**_____

- Enter your group members' names to the right
- Place a check mark beside tasks demonstrated by each member

		Self Evaluation			
Performance Tasks					
Initiate	Proposes tasks, goals, or actions. Defines group problems, suggests a procedure.				
Inform	Offers facts, gives an opinion that educates the group.				
Clarify	Interprets ideas or suggestions, defines terms, clarifies issues before the group, asks for further facts, opinions or feelings.				
Summarize	Pulls together related ideas, restates suggestions, offers a decision or conclusion for the group to consider.				
Reality Test	Critically analyzes an idea, tests ideas against data, tests whether an idea will work.				
Resource	Brings in outside or unexpected resources.				
Reflect	Reminds the group to stop and reflect, think carefully and critically.				
Insights	Provides good, novel ideas or insights.				
Set Standards	Sets the standards for group performance and interaction.				
Maintenance Tasks					
Harmonize	Reconciles disagreements, reduces tensions, helps people explore differences.				
Encourage	Is friendly, warm and responsive to others, indicating by facial expressions or remarks the acceptance of others' contributions.				
Compromise	Admits error, modifies position in the interest of group growth or cohesion, offers a compromise when own ideas are involved in a conflict.				
Gate Keep	Facilitates participation of others, suggests procedures that permit sharing remarks, helps to keep channels of communication open.				
Feedback	Constructively tells others how their behaviour affects group members and process.				
Consensus Test	Asks whether the group is near a decision, tests possible conclusions.				
Organize	Prepares the agenda, contacts members (emails, phone, etc.).				
Follow	Follows the lead and accomplishes the important work.				
Inhibiting Tasks					
Aggress	Deflates other's status, attacks the group's values, jokes in a way that causes harm.				
Block	Opposes or resists the group's wishes for personal reasons, and stops the group from moving forward.				
Dominate	Asserts authority or superiority, speaks excessively, interrupts contributions of others, controls by means of flattery or patronizing behaviour.				
Out-in-Left-Field Behaviour	Makes a display of disagreement or lack of involvement. Seeks recognition in ways not relevant to the group task.				
Avoid	Stays off subject, or pursues other interests, usually to avoid commitment.				
Digress	Draws the group off task or topic. Persists when most are ready to move on.				
Special Pleading	Introduces or promotes ideas related to one's concerns, beyond what is helpful.				
Withdraw/ Silent	Acts indifferent or passive. Resorts to excessive formality, doodling, whispering, using electronics, etc. Silent so the group does not benefit from your knowledge/skill.				
Absent/Late	Misses meetings without notice, misses meetings repeatedly or arrives late regularly.				
Unprepared	Repeatedly arrives at meetings without necessary preparation.				

Criteria	Descriptors	
	Satisfactory	Unsatisfactory
Responsibility	• completes assigned tasks	• fails to complete assigned tasks
	• participates actively	• participates marginally in tutorials
	• listens to others	• does not listen
	• adds information where appropriate	• confuses others with inappropriate comments
	• encourages participation of others	• does not encourage participation of others.
	• does not impede tutorial process by interrupting	• impedes tutorial process by interrupting
	• facilitates learning of others	• does not facilitate the learning of others
Information	• brings in information which is new, relevant, and complements that brought by others	• brings in no new information or provides irrelevant information
	• uses a variety of sources (texts, journals, reviews)	• uses very few sources of information
Communication	• communicates ideas clearly/ concisely	• rambles on or is inaudible
	• ensures that others are not confused by information presented	• confuses others
Challenge	• justifies comments with appropriate references	• fails to justify comments made
	• promotes a deeper understanding of the subject	• fails to promote a deeper understanding of the subject
	• challenges information brought, permitting others to evaluate relevance/significance of their comments	• fails to question/challenge others and thus does not permit them to assess relevance/significance of their comments
Self-assessment	• recognizes strengths and weaknesses	• fails to recognize personal strengths and weaknesses
	• accepts criticism gracefully	• fails to accept constructive criticism gracefully
	• identifies means to correct weaknesses	• becomes defensive and argumentative and does not identify means to correct weaknesses
	• demonstrates effective action to correct weaknesses	• fails to demonstrate effective action to correct weaknesses

Figure 2 Student profile

David, T., Patel, L., Budett, K. & Rangachari, P. (1999). *Problem-Based Learning in Medicine : A Practical Guide for Students and Teachers.* The Royal Society of Medicine Press.

(Ring ONE number)

IN THE POOR GROUP		IN THE SATISFACTORY (COMPETENT) GROUP		IN THE OUTSTANDING GROUP
Group evaluations rarely occur		Evaluation sessions happen sometimes		Evaluation sessions are planned frequently
Members never self-evaluate		Members sometimes self-evaluate		Members often self-evaluate
Members show little motivation		Members are keen to improve their functioning as a group		Members are committed to continuous improvement in their functioning
WHEN GIVING FEEDBACK:				
People make general comments		Most comments are specific and concrete		All comments are clearly described and refer to specific behaviours
People make judgements and interpretations		Most comments are descriptive and not judgemental		People never make judgements and always refer to actual behaviour
Comments are not timely		Comments are usually well-timed		Comments are always well-timed
Few members contribute to feedback sessions		Most members contribute to feedback sessions		All members contribute to feedback sessions
Comments are critical and rarely supportive		Most comments are supportive and rarely critical		All comments are supportive and never critical
Comments often start with negative points		Most comments often start positively and finish with negative points		All comments start positively and finish with what could be improved
Clear points for improvement are rarely resolved		Clear points for improvement are usually identified		Specific points for improvement are always identified
Improvement does not occur, and problems continue to happen		Improvement often occurs based on evaluation		Targeted areas always improve after evaluation sessions

Figure 1 An assessment instrument — Manchester model — for evaluation and feedback

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4

MODELS FOR PROBLEM-BASED INSTRUCTION IN UNDERGRADUATE COURSES

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Chapter Summary

Problem-based learning is a teaching technique used in many medical schools to facilitate learning basic science concepts in the context of clinical cases. This model is not generally applicable to many typical undergraduate courses for a variety of reasons, including class size. This chapter discusses several instructional models used in medium to large classes.

Introduction

In the early 1990s when I first became aware of problem-based learning (PBL) in the medical school setting, I was immediately interested in it because I believed that the process of learning in PBL most closely mimics how we question and learn in our professional lives. I was also aware, however, that what worked in a medical school setting might not transfer well into a typical undergraduate setting for a variety of reasons, including intellectual maturity and motivation level of the students. I found that in order to incorporate PBL in undergraduate courses, it was necessary to develop models of instruction

that allow one faculty member to teach large numbers of typical undergraduate students. There are a variety of instructional decisions that need to be made based on several factors, including size of class, intellectual maturity of students, course objectives, preference of instructor, and availability of undergraduate peer tutors or graduate teaching assistants.

Instructional Models

When the "early PBL reformers" at the University of Delaware started to develop their first problem-based courses, each instructor made his or her own decisions on the best way to use problem-based instruction for their students. At the same time, those faculty members were talking to one another, sharing what was working in their course, what wasn't working, and brainstorming ideas for overcoming some of the problems they encountered in adopting problem-based techniques in their typical undergraduate classes. Out of those discussions and early adoptions, several models of problem-based instruction were identified and have been used by increasing numbers of faculty who teach undergraduates in a variety of undergraduate institutions.

Medical School Model

Problem-based learning is a teaching technique used in many medical schools to facilitate learning basic science concepts in the context of clinical cases (Boud & Feletti, 1997). In many cases, students are assigned to groups of eight to ten, and each group is assigned a faculty member who plays the role of tutor or discussion leader as the students work through a case or problem. This model is very student-centered, with little or no formal class time. Instead, groups schedule time that they will meet to discuss the materials. Since typical undergraduate classes are larger, most instructors would be unable to use the classic medical school model, except in smaller, senior-level seminar-type classes.

Some faculty have used graduate students, recruited outside professional experts, or invited other faculty into their course to serve as additional tutors in their course in order to mimic the medical school model as closely as possible. Others have recruited undergraduate students to serve as peer tutors (see Chapter 8 for more detail).

Floating Facilitator Model

A variety of instructional strategies can be used to facilitate the learning of multiple groups of students in larger size classes. When it is not possible to

have a dedicated faculty tutor lead discussion, answer questions, and ensure equal participation from all students, it is best to limit the size of each group to four, at most five students. Johnson, Johnson, and Smith (1991) recommend that students be assigned to groups of four in order to improve student accountability and assure that each student gets his or her own "talk time." It is also easier to plan group activities that require the effort of four students rather than a larger group.

In this model, only a portion of class time will be devoted to individual group discussion, while the instructor as the "floating facilitator" moves from group to group asking questions and probing for student understanding. Other periods of time will be spent having each group report to the whole class on the results of individual discussions. Minilectures and whole class discussions will also play a role in this model, as well as other activities, such as debates and presentation of project results or problem solutions. Using a variety of learning activities has the advantage of appealing to the diverse learning styles of the students in the course.

The following is an example of activities in a typical class the day after the first stage of a problem has been introduced and the students have had an opportunity to do research on their initial learning issues:

- Introduce the schedule for the day.
- Students within their groups discuss the findings of their research on learning issues that were previously identified for the first 15–20 minutes. Groups then rank, in order of importance, the learning issues from the previous class and add new learning issues that have emerged from group discussions. Students use this time to teach each other what they have learned so far about the concepts targeted in the problem. During this time, the instructor moves from group to group asking questions, directing discussion, and checking for understanding. It is important not to get stopped by one group for too long. All groups want to feel that they have access to the teacher during the individual group time. One common student complaint will be, "We were stuck and wasted class time waiting 15 minutes to get help." If all groups seem to be "stuck" on the same issue, it is best to suspend group discussion while the instructor clarifies the topics through a minilecture or whole-class discussion.
- Each group reports to the whole class on what their top-ranked learning issues are and what they have learned so far through their research. This "reporting out" procedure is helpful to the instructor, as

well as to each of the groups. When listening to other groups' learning issues and findings, each group will be getting feedback on their own choices and research. If most groups' top-ranked learning issue was at the bottom of another group's list, those students will have an opportunity to rethink how they have approached the problem before going further. If the groups are split, the instructor has an excellent opportunity to initiate a discussion on the rationale used by various groups and perhaps redirect some students who were missing the "big ideas" and important concepts in the problem. This is also a good time for the faculty member to recommend helpful learning resources for students if they don't appear to have found them.

- Once a list of the groups' learning issues has been generated, and there has been a discussion about the research done on those questions, the instructor may want to conduct a class discussion or plan a minilecture to focus on the questions that are outstanding with most groups. One may choose to reflect on the major learning objectives addressed by the problem, particularly if the students seem confused or lack direction. At the same time, PBL practitioners will highlight important learning issues students have not identified and direct students to other materials and resources they have missed in their research.
- After some whole-class activities, the instructor can cycle back to individual group work, asking students to reevaluate their list of learning issues after hearing the responses from other groups and instructions from the teacher. They also may identify new questions that may have been generated by the class discussion or minilecture. While students are discussing issues in their group, one can circulate among them listening to group discussion and questions.

Before introducing the second stage, the faculty member may want to summarize the first stage of the problem, soliciting remarks from each student group in terms of answers to questions and resolution of important learning issues. The cycles between group discussion and whole-class activities will help the instructor keep informed of what and how the groups are doing and will also be a mechanism for timing the progress of all of the groups, ensuring that a few groups don't get too far ahead or behind.

Peer Tutor Model

Undergraduate peer or near-peer tutors can be utilized to extend the ability to check the functioning of individual groups and assure that the group discussions

probe for deeper levels of understanding. Peer tutors can help incorporate an instructional model that is closer to problem-based instruction in medical schools. Peer tutors are especially effective in the following ways:

- They help smooth the group and problem-solving process, accentuating the positive aspects of group learning and minimizing the negative ones.
- They serve as a role model in the PBL process for inexperienced students, facilitating student response and participation from everyone in the group. Peer tutors who were previous students in the course can reassure and support students, particularly freshmen, when they feel challenged.
- Peer tutors check the content of the discussion, looking for conceptual understanding.
- They also make decisions about when to answer student questions and when to throw questions back to the students.
- Tutors serve as the instructor's window into their groups, informing him or her of what is working well and what is not. Feedback from peer tutors is very informative to the instructor.

Just as in the medical school model, peer tutors can serve the role of group facilitator to a larger group (six to eight students) since they will be in a position of monitoring the group function on a regular basis. In large classes where there are not enough tutors for each group, they can serve in a rotating or "floating facilitator" role with two or three groups of four students. This role is more difficult for peer tutors (as it is for faculty). If this model is used, it may be desirable to script appropriate probing questions and dialogue for the peer tutors to use as they move from group to group. This strategy, although somewhat structured, ensures that each group is effectively guided toward achieving the course instructional goals. More details about peer tutors and how to prepare undergraduates to be successful group facilitators are found in Chapter 8 of this book.

Large Class Models

Problem-based instruction can be implemented in large courses, although the structure of the class will need to be more teacher-centered than in the previous models. Undergraduate peer tutors or graduate assistants can be used in this model as floating facilitators to provide support that will assist in group

discussions and classroom management. When implementing PBL in large courses, teachers need to design additional structure into group activities during class time. The instructor's role will be similar to that of the discussion leader's—asking students to do the following:

- Discuss instructor-generated questions.
- Rank learning issues.
- Report results.
- Share resources.
- Ask probing questions.

A PBL instructor will want to plan to use many teaching strategies that will challenge students to develop critical thinking skills and communication skills and still support them in a way that allows them to accept the challenges of learning from themselves and their peers. When planning a PBL class, recognize that it will be important to cycle through many instructional activities that will include minilectures, whole-class discussion, and small group discussion. The daily routine may be somewhat like the one mentioned under the "floating facilitator" model, but the faculty member will need to limit the time that groups spend in individual group discussion. Rather than plan for a twenty-minute period of group discussion, it will be more successful to break the group discussion time into two ten-minute periods with whole class discussion or a minilecture in between. More details about teaching large classes using PBL can be found in Chapter 14.

Conclusion

Incorporating PBL into typical undergraduate courses, particularly at research universities, is a challenge that is worth meeting in order to help undergraduate students develop the lifelong learning skills that will help them succeed in college and beyond. Many models for successfully using PBL in medium- to large-size classes have been discussed in this chapter, and more details of these models are discussed in Part Three of this book. Each faculty member intent on using problem-based instruction will make many decisions based on the size of their class, the intellectual maturity of their students, the type of course (survey course, introductory, majors' upper level), and the availability of graduate or undergraduate peer tutors.

Author Biography

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5

WRITING PROBLEMS FOR DEEPER UNDERSTANDING

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Chapter Summary

One of the keys to success in implementing problem-based learning in undergraduate courses is the type of problem you use. This chapter will discuss ways to find or write PBL problems if there are no sources of them in print.

Introduction

A common complaint heard from college faculty is that their students seem to lack the ability or motivation to go beyond factual material to a deeper understanding of course material. The reasons for superficial rather than deep understanding on the part of students are many, including how we test, what expectations we set, and what learning materials we use when we teach. This chapter will focus on using new materials and problems in a problem-based environment to help students achieve in-depth knowledge of the concepts central to their understanding course material.

Standard college textbook problems in science and other disciplines tend to reinforce the students' naive view of learning because they can successfully answer homework end-of-chapter problems through memorization of facts and equations and using novice "pattern-match" problem-solving techniques. Typical problems do not foster the development of effective problem-solving

and analytical skills (Heller & Hollabaugh, 1992) nor do they challenge students to develop critical thinking skills and logical reasoning (Mazur, 1996). In a successful PBL course, the selection of appropriate problems and material is crucial for students to go beyond a superficial understanding of the important concepts and principles being taught.

Characteristic of Good PBL Problems

There may be more characteristics of good PBL problems than those in the following list, and those characteristics may vary somewhat according to the discipline. However, many practitioners of problem-based instruction will probably identify the following as important characteristics of a good PBL problem:

1. An effective problem must first engage students' interest and motivate them to probe for deeper understanding of the concepts being introduced. It should relate the subject matter to the real world as much as possible. If the problem is placed in a context in which the students are familiar, they will feel that they have a stake in solving the problem.
2. Problems that work well sometimes require students to make decisions or judgments based on facts, information, logic and/or rationalization. In this kind of problem, students will be asked to justify their decisions and reasoning based on the principles being learned. Problems may require students to decide what assumptions are needed (and why), what information is relevant, and/or what steps or procedures are required in order to solve the problem. Not all the information given in the problem needs to be relevant to a solution, as is the case in "messy" real-world situations, and not all the information needed for a solution will be given to the student right away. For this reason, many PBL problems are designed with multiple stages, to be given to student groups one at a time, as they work through the problem. The second stage of the problem may give additional information to students related to issues raised in the first stage of the problem.
3. The problem should be complex enough that cooperation from all members of the student group will be necessary in order for them to effectively work toward a solution. The length and complexity of the problem or case must be such that students soon realize that a "divide and conquer" effort will not be an effective problem-solving strategy. It may be necessary and, in fact desirable for groups to assign different learning issues to individuals to research. The power of problem-based learning, however, lies in the ability of the group to synthesize what they have learned and connect that new knowledge to the framework of understanding that they are building, based on the concepts in the course. This requires cooperative learning and group discussion as opposed to individual compartmentalized learning. For example, a problem that consists of a series of straightforward "end of chapter" questions will be divided by the group and assigned to individuals and then reassembled for the assignment submission. In this case, students end up learning *less* not *more*.
4. The initial questions in the first stage of a problem should be open-ended, based on previously learned knowledge, and/or be controversial so that all students in the groups are initially drawn into a discussion of the topic. This strategy keeps the students functioning as a group, rather than encouraging them to work individually at the outset of the problem. Again, the initial discussions will help students remember what they already know and help them build connections to previously learned concepts and material.
5. The content objectives of the course should be incorporated into the problems, connecting previous knowledge to new concepts, and connecting new knowledge to concepts in other courses and/or disciplines. Many faculty share the content objectives of the problem with students after they finish the problem to ensure that all groups researched each objective, and if not, they still have an opportunity to do so. Instructors usually prefer to wait until students are through so that they will not limit the scope of their investigations, but they do want to give students the benefit of seeing the instructor's objectives as a check on their learning. PBL practitioners may also choose to share the broader objectives of the problem at the beginning of the problem to focus students before they identify learning issues. The problem's questions should challenge students to develop higher-order thinking skills, moving them beyond Bloom's (1956) lower cognitive levels of knowledge and comprehension to the higher Bloom levels, where they analyze, synthesize, and evaluate (Table 5.1). These are the skills that are so important for our students to develop in order to succeed in any profession.

Table 5.1 Bloom's Cognitive Levels

Cognitive Level	Student Activity
Knowledge	Remembering facts, terms, concepts, and definitions
Comprehension	Explaining and interpreting the meaning of material
Application	Using a concept or principle to solve a *new* problem
Analysis	Breaking material down into its parts to see interrelationships
Synthesis	Producing something new from component parts
Evaluation	Making a judgment based on criteria

Suggestions for Writing PBL Problems

Finding good PBL problems is a challenge in most disciplines. They generally are not found in traditional texts, so the search for material for a problem-based course takes a certain amount of creativity. Some faculty use video clips, stories, novels, articles from the popular press, and research papers as the basis of a problem. Frequently, veteran PBL faculty may use a typical textbook problem and rewrite it as an open-ended, real-world problem. The process of developing a multistage PBL problem may differ from one discipline to another, but generally, the following steps can help instructors write problems for any course:

Step 1. Choose a central idea, concept, or principle that is always taught in a given course, and then think of a typical end-of-chapter problem, assignment, or homework that is usually assigned to students to help them learn that concept. List the learning objectives that students should meet when they work through the problem.

> *For example: In an introductory physics course, I teach conservation of momentum. In a typical textbook for this course, students would be expected to solve simple collision problems (two objects colliding, such as pool balls, a bullet and a stationary block of wood, two cars) in which most or all of the necessary information is given. As stated by Mazur (1996), with these typical problems students tend to pattern-match and then "plug and chug" to find a solution.*
>
> *My content objectives in a traditional course would include the following:*
>
> 1. *Understand and be able to solve conservation of momentum problems involving elastic and inelastic collisions.*
> 2. *Understand and be able to explain the role of force, motion, and energy in elastic and inelastic collisions.*

Step 2. Think of a real-world context for the concept under consideration. Develop a storytelling aspect to an end-of-chapter problem, or research an actual case that can be adapted, adding some motivation for students to solve the problem. A complex, ill-structured problem will challenge students to go beyond simple plug-and-chug to solve it. Look at magazines, newspapers, and articles for ideas on the story line. Some PBL practitioners talk to professionals in the field, searching for ideas of realistic applications of the concept being taught.

> *For example: I decided to use an automobile accident scenario as the context for my problem. My new objectives would be expanded to include the following. Students should be able to do the following:*
>
> 1. *Use understanding of the principles of forces, motion, momentum, and energy to design a plan to reconstruct a car accident.*
> 2. *Explain how frictional forces related to varying surfaces affect the motion of an object.*
> 3. *Calculate the velocities of two vehicles before and after impact using physics principles, such as forces, motion, mechanical energy, and conservation of momentum.*
> 4. *Evaluate real-world data related to a car accident in order to make a judgment about the drivers' fault.*
> 5. *Find and use appropriate learning resources to aid in reconstructing the accident.*
> 6. *Explain how safety devices, such as seat belts, airbags, and crumple zones work in terms of force, motion, momentum, and energy.*

Generally, the learning objectives for students in a problem-based course include objectives beyond the content objectives found in a traditional course. Problem-based learning objectives may be more complex and involve process skills objectives, such as number 5 in the previous list. Chapter 9 of this book describes the importance of learning objectives in more detail.

Step 3. The problem needs to be introduced and staged so that students will be able to identify learning issues that will lead them to research the targeted concepts. Some questions that may help guide this process follow:

- What will the first page (or stage) look like? What open-ended questions can be asked? What learning issues should be identified?
- How will the problem be structured?
- How long will the problem be? How many class periods will it take to complete?

- Will students be given information in subsequent pages (or stages) as they work through the problem?
- What resources will students need?
- What end product will students produce at the completion of the problem?

Many times, PBL problems are designed as multistage or multipage and may take student groups a week or more to complete. Not all the information needed to solve the problem is given in the problem, or chapter, or perhaps even in the textbook. Students will need to do some research, discover new material, and arrive at judgments and decisions based on the information learned. The problem may have more than one acceptable answer, based on the assumptions students make.

> *For example: The problem I wrote about a car crash ("A Day in the Life of John Henry" is at the end of this chapter) begins by asking students to decide what questions a police officer needs to be able to answer in order to decide who is at fault in an accident. What measurements and data need to be gathered? What physics principles will be needed to analyze the crash scene? These questions are designed to encourage students to talk about what they already know about car crashes and what they have already learned about the physics involved.*
>
> *The four-page problem takes students a week to work through, as they research and learn about momentum, accident reconstruction, safety devices, and then they apply that knowledge to make assumptions and judgments about the cause of the accident.*

Step 4. Write a teacher guide detailing the instructional plans on using the problem in the course. If the course is a medium- to large-size class, a combination of minilectures, whole-class discussion, and small group work with groups regularly reporting may be necessary (see Chapter 4). The teacher guide can indicate plans or options of cycling through the pages of the problem interspersing the various modes of learning.

> *As students worked on the "John Henry" problem, they spent time in their individual groups discussing answers to questions posed in the problem, sharing information they learned in individual research, and arriving at conclusions based on their assumptions and calculations. The student group time was interspersed with whole-class discussion, allowing time for individual groups to share with other groups their findings, conclusions, and questions. I also intervened with minilectures to clarify issues or demonstrate specific models for analyzing certain aspects of the problem. They also had the opportunity to develop hands-on experience in a laboratory setting. The end product that groups produced was a group written report of their solution to the problem, justifying their position by citing physics principles involved.*

Step 5. The final step is to identify resources for students. Students need to learn to identify and utilize learning resources on their own, but it can be helpful if the instructor indicates a few good sources to get them started. Many students today will want to limit their research to the Internet, so it will be important to guide them toward the library as well.

Conclusion

Writing problem-based learning problems may be time consuming, challenging, and sometimes frustrating. However, the process of thinking through the learning priorities of a course and finding, adapting, or writing complex, realistic materials to meet those learning priorities will change how an instructor views his or her course in the future. Any magazine or newspaper article, documentary, news report, book or movie that is seen will become possible material for new problems for a course. Faculty will gain a new appreciation for the concepts and principles that they teach, and the connections that should be made to concepts in other courses and disciplines. It is always revealing to grapple with such questions as "How is the knowledge of this concept used in the world outside the classroom?" or "Why do my students need to know this?" or "How will my students use this knowledge in future courses?" I believe that writing PBL problems can help faculty develop into more reflective teachers.

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Part 4

Lt. Henry measured the skid marks made by both vehicles prior to impact. The skid marks for vehicle 1 were 20 feet in length and for vehicle 2 were 7 feet in length.

- How fast were both cars going just prior to hitting their brakes?
- Which driver do you recommend John Henry cite in the accident? Justify your answer, since Lt. Henry will need to make an airtight case in court.

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6

STRATEGIES FOR USING GROUPS

Deborah E. Allen, Barbara J. Duch, and Susan E. Groh

Chapter Summary

In problem-based learning, students are asked to work together to analyze and resolve problems, and to communicate, evaluate, and integrate information from diverse sources. Effective performance of these group learning tasks requires the development of new skills on the part of both the student and instructor. This chapter discusses strategies an instructor can use to maintain functional groups in the classroom—groups in which all members work effectively to enhance their own and each other's learning.

Introduction

A team of students had four members called Everybody, Somebody, Anybody and Nobody. There was an important job to be done. Everybody was sure that Somebody would do it. Anybody could have done it, but Nobody did it. Somebody got angry about that because it was Everybody's job. Everybody thought Anybody could do it but Nobody realised that Everybody wouldn't do it. It ended up that Everybody blamed Somebody when Nobody did what Anybody could have done. (Gibbs, 1995)

Collaborative learning is an essential feature of problem-based learning (PBL). Working in PBL groups toward common goals can benefit students by lessening their sense of isolation (Seymour & Hewitt, 1997) and thereby fostering the development of learning communities (MacGregor, 1987). Courses that incorporate small-group learning can have a positive effect on students' academic achievement, persistence through courses and programs, and attitudes toward learning when compared to their more traditionally taught counterparts (Bonwell & Eison 1991; Johnson, Johnson, & Smith, 1991, 1998; Springer, Stanne, & Donovan, 1999). Frequent exposure of students to collaborative and cooperative learning reinforces the collaborative nature of scholarship and inquiry (American Association for the Advancement of Science, 1989). It introduces a new social structure to the classroom—one of negotiated relationships between students, and between student groups and the instructor, helping students to become articulate, autonomous, and socially mature (Michaelson & Black, 1994).

Conversely, classroom experiences with collaborative and cooperative grouping can leave students feeling (to varying degrees) cheated by group members who have not pulled their weight, held back by slower students, discounted by more assertive group members, or shortchanged by the course instructor because they have had to teach themselves. As Felder and Brent point out (1996), although student-centered instruction can yield tangible benefits, "they are neither immediate nor automatic." There are many ways that groups can fail (Feichtner & Davis, 1985).

For that reason, activities that promote a good atmosphere for collaborative learning are never a waste of classroom time. They can lead to more productive learning and reduce the time that both students and instructor might otherwise spend diagnosing and mediating the sources of group conflict. This chapter will focus on practical strategies (accessible to any instructor) for promoting the development of student groups that act cohesively, yet display a high degree of individual accountability for the work required.

Getting Started with Groups

Most instructors using a student-centered method, such as problem-based learning, recommend that group work be started early in the course—preferably the first day of class. If the enrollment of the course is not stable at this point, these earliest groups need not be the permanent ones in which students will work later on. On the first day of class, a common strategy is for the instructor to explain why he or she thinks using groups is a good strategy, then ask students to report on past experiences they have had working in teams. Student accounts

of negative experiences can prompt opportunities to reassure the class with a point-by-point description of the mechanisms in place to help prevent negative experiences in the present course.

The first day of class is also a good occasion to conduct what will be the first of many activities that promote positive group interactions. Examples of these first-day activities include the following:

1. Writing a group biography (including such items as hometowns, career goals, and favorite courses)
2. Taking a short pretest on course content given first to individuals, then to groups. Students will no doubt find that the group score is better than any individual score within the group. (This can also serve double-duty as a preassessment mechanism for uncovering students' misconceptions about the upcoming course material.)
3. Completing a learning style survey such as the Kolb Learning Style Inventory (1985). The results can be used for group discussion of the effect that the individual preferred learning styles might have on group function.
4. Engaging in mental games that require the skillful use of teamwork to complete or that make a point about the distinction between student- and instructor-centered learning environments, such as "Stand and Deliver," described in Chapter 7.

Forming Groups

Creation of heterogeneous groups can expose students to new ideas and distribute assets and liabilities evenly (Michaelson & Black, 1994). Heterogeneous groups can either be selected intentionally or randomly (by counting off on the course roster or by having students count off in class, for example). Information for intentional selection of attributes to be balanced across groups can be based on student records (major, year in school), or on information provided by students (existence of special skills, desired grade in the course, course and work schedules on- or off-campus residence, etc.). Collaborative learning can be a particular success story for minority students (Fullilove & Treisman, 1990; George, 1994). Felder et al. (1995), however, recommend that minority students (ethnic minorities or women in traditionally male disciplines) not be isolated in groups, in order to reduce the possibility of the discounting or devaluing of their ideas.

Monitoring Groups

Instructor's Role

In the early model of PBL, each faculty "tutor" guided a single student group. Although the role of the well-functioning classic PBL tutor is far from easy, the one-on-one nature of his or her interaction with a group allows for spontaneous and informal interventions that continually fine-tune the reasoning process, assure evenness of participation, keep the group moving forward in the problem, promote good interpersonal relationships, and help the group learn how to direct its own learning. In all but the smallest of undergraduate classes, the instructor must resort to other strategies, often more structured and formal, to help optimize the functioning of the multiple-classroom groups. These strategies include (1) having well-defined group activities, (2) using PBL problems that allow for instructor interventions at key points (in a large class, for example, at roughly 10–15 minute intervals) to bring the class together for discussion and/or clarification, and (3) walking around the classroom as groups work to look for and help remedy obvious signs of group dysfunction. These signs include conversations that are off task; students who don't take part in the discussion or conversely, dominate it; and physical behaviors, such as reading while others are talking, or sitting back and slightly apart from other group members.

Peer Group Facilitators

An excellent way for a PBL instructor to extend his or her observational and group guidance range is to invite undergraduates who have taken the course to return and serve as peer group facilitators. Strategies for recruiting, preparing, and supporting the efforts of these peer group facilitators are discussed in Chapter 8.

Ground Rules

Another way to encourage students to take ownership of their effective performance as a group is to ask them to establish and enforce group ground rules in the first week or two of class, before negative behaviors have a chance to take root. This set of standards and expectations, written after groups have discussed the behaviors that they will not tolerate, helps to establish norms for group behavior. Many instructors, particularly in courses taken by students who are new to collaborative learning, provide examples of "rules of the road" that are minimally essential for good group function: (1) come to class on time, (2) come to class prepared, (3) notify members of the group ahead of time if class must be missed for any reason, and (4) respect the views, values,

and ideas of other members of the group. Some instructors mandate that these essential behaviors be included in the ground rules, allowing student groups to draft additional codes of behavior they feel are necessary.

As in the world outside the classroom, rules tend to be broken or ignored if they have no teeth. For this reason, in many PBL courses, ground rules are not considered complete unless there are stated consequences for violators. Some examples of consequences that student groups have drafted are to have the instructor lower the violator's grade (to zero if appropriate) for assignments to which he or she didn't contribute, or to give extra assignments or share of responsibilities to make up for missed work. Students seldom suggest permanent or even temporary shunning of a group member, despite being informed by the instructor that this is conceivable and would be upheld. Some instructors perceive that their students seldom resort to imposing their own penalties for ground rule violation, and instead distribute a description of recommended steps to take when disturbed by another group members' behavior (see "Conflict Resolution"). In most courses, groups are asked to sign two copies of their ground rules and consequences, give one copy to the instructor, and keep one in a group notebook.

Group Roles

When each student feels individually accountable for his or her own performance, "free riders" are discouraged and contributors to the group effort are rewarded. One way to promote individual accountability and lower barriers to participation is to ask students to take on roles of responsibility in their groups. Common strategies include formulating a role for each student in the group and asking students to rotate the roles among group members every week or after every problem or assignment. This discourages students from sticking to roles that come to them easily and gives them additional experience in those that they find more challenging.

Commonly assigned roles of responsibility include the following:

- Discussion Leader. Keeps the group on track; maintains full participation.
- Recorder. Records assignments, strategies, unresolved issues, data; convenes group outside of class.
- Reporter. Reports during whole-class discussion; writes final draft of assignments.
- Accuracy Coach. Checks group understanding; finds resources.

Some practitioners of collaborative teaching and learning strategies depend on assignments, practices, and their grading systems to foster the development of group cohesion (Michaelson, 1997–1998), rather than rotating roles.

Evaluation

Allowing classroom opportunities for students to provide constructive verbal and written feedback to individuals and their groups is another strategy for reinforcing positive group behaviors and maximizing individual accountability. Verbal group feedback sessions work best if scheduled at the end of each problem (at least two to three times a semester) or whenever a group is not functioning well. Feedback sessions typically begin with each individual in the group stating what the group did well since the last session and how he or she thinks the group needs to change or improve to function better. Sessions should ideally end with each group setting goals that will help remedy any perceived problems. For example, if a group tends to drift into talk about personal issues, it may decide to monitor the accuracy coach and discussion leader roles more closely in the future to help keep the discussions on task.

After the overall functioning of the group has been discussed, many instructors ask students to rate their individual contributions to the group effort using written evaluation forms (see Allen & Duch, 1998 and Chapter 11 for examples of these forms). Typically, the instructor predetermines the ratings criteria on these forms. Each student fills out the form in a confidential manner, rating the effort of the other members of the group as well as him- or herself on a scale of one to five and writing a few sentences of specific comments for each individual student. Instructors then compile the average ratings and summarize all comments to be given to each student, ensuring that students can be candid in their comments. The results of the ratings should be factored into each student's grade.

This feedback is not only an important reality check for students, but is invaluable in helping the instructor detect the signs of a malfunctioning group. When evidence that group members are not contributing well presents itself in these forms, early intervention is possible. Before the first feedback session of the course, it helps to review for the class the basic guidelines for giving good feedback (Gibbs, 1995). That is, good feedback is specific, focuses on behaviors and actions rather than personality or similar personal attributes, describes rather than criticizes or demeans, is presented as perceptions or feelings rather than as absolutes, and focuses on behavior that can be controlled or changed.

Finally, larger group projects, assignments, and products may also require feedback about the extent and nature of each group member's participation to ensure individual accountability and discourage free riders.

Group Activities

Jigsaw Grouping

In a PBL course, students gradually become accustomed to discussing learning issues within their group, doing research, and teaching each other in order to work through a problem. For some problems, use of a jigsaw group scheme can be an effective way to encourage students to research one point of view or learning issue in depth with others before sharing that information with his or her permanent (base, or home) group (Slavin, 1995). In a jigsaw group scheme operating in a PBL context, students begin a problem in their permanent group and are then assigned a new group (the jigsaw or expert group) in which to work with others who are also gathering evidence to support a particular viewpoint or researching the same learning issues. Each individual in the permanent, home group chooses a distinct point of view for which he or she will become an advocate. All students now form the new (jigsaw) groups that are specific to their point of view. In a jigsaw group, discussion focuses on issues that will influence that group's position on the problem. Each member of the jigsaw group is assigned learning issues to research, then shares information and constructs evidence to support the group's viewpoint. Students then return to their base to advocate for their jigsaw groups' position. Typically, the base groups must then reach consensus on a position with regard to a dilemma or proposal linked to the original problem and list the reasons for the group decision. Whole-class discussion or debate can then follow, with all groups (ideally) fully prepared to provide substantive evidence for their consensus opinion.

Assignments

In a problem-based learning course, the instructor may plan to have groups work through a series of problems, design and implement a project related to a problem or specific concepts in the course, develop a concept map (Allen & Duch, 1998), research and develop a problem of their own, complete a homework assignment, or a variety of additional activities. A number of decisions need to be made in planning such activities, including how to structure an assignment so that all group members will be involved, whether individual students or the entire group will be responsible for a written or presentation product, and whether the

product will be graded or not. Assignments requiring an out-of-class component, such as library or web research, can be designed to allow division into parts; joining these parts into a coherent whole, however, should require the resources of the entire group working together. This presents a challenge for the instructor: Students will quickly use a "divide and conquer strategy" if they perceive that the individual parts can just be assembled for the final product with no group interaction. One strategy to increase group cohesiveness is to require members to make a concrete decision based on the analysis of a complex issue. Students quickly realize that the group effort is invaluable in this type of assignment, since individual members' input is such a valuable resource.

At the same time, it is essential to make provisions to ensure individual accountability in group assignments. One suggestion used by many PBL practitioners is to have students individually or collectively distribute the total points for the assignment among themselves in proportion to the effort each one put into it. Another is to call randomly on individual team members to present sections of project reports or critical solutions to problems, with everyone in the group getting a grade based on the selected student's response (Felder & Brent, 1995). Similarly, one might assign each student the responsibility of writing his or her own solution to a problem after the group discussions; this, however, can become burdensome to the instructor if the class is large.

Resolving Conflicts

Group ground rules, roles of responsibilities, documenting the activities of the group and individuals within the group, and peer pressure within the group all provide ways to help group members avoid conflict. The instructor should communicate clearly to the class that each student is responsible for monitoring the functioning within his or her group, as well as the academic standards of the discussions, assignments, and research reported. If students are in a group with another person who resists working as hard as the rest of the members, then the group-monitoring methods stated previously will provide safe, objective mechanisms through which the group can give the errant individual truthful and direct feedback concerning his or her performance and the group's expectations. The instructor should also make it clear to students that she or he will assist them in dealing with group conflict, including direct intervention if necessary. This intervention may take the form of a request that a group rewrite their ground rules and consequences, or the suggestion that the group conduct an extra feedback session, or a requirement for the group to meet regularly with the instructor until the conflict is resolved. It is important to remember that conflict is not entirely negative and that it is good training for students to learn to resolve conflict and facilitate troubled groups

Conclusions

For the many faculty members who did not experience group learning as students, undertaking an instructional shift from traditional lecture (with its emphasis on individual learning) to group-centered problem-based learning may be rather intimidating; the same will certainly be true for many students. It is important, therefore, to reassure both students and faculty that the benefits of cooperative learning are well documented (see Johnson, Johnson, & Smith, 1991 & 1998). By structuring a course with group ground rules, roles of responsibility, and individual accountability, the PBL practitioner can greatly curtail, if not eliminate entirely, the ability of "slackers" to benefit from the hard work of others in the group. Knowing that their individual efforts will be recognized and protected gives students the freedom to take full advantage of the power of groups in developing knowledge with and for one another.

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7

GETTING STARTED IN PROBLEM-BASED LEARNING

Harold B. White, III

Chapter Summary

The transition from traditional instruction to a problem-based approach to learning requires many changes and, without proper preparation, can frustrate the best intentions. Among the issues one needs to address are preparing a syllabus that reflects revised learning objectives, finding appropriate problems to address content, introducing students to group process and learning skills, and dealing with the uncertainty of a different classroom strategy.

Introduction

It takes a certain amount of independence and determination to change the way one teaches. It also takes time and involves risks. Where do instructors acquire the commitment to get started with problem-based learning (PBL)? Frequently, commitment grows out of the recurring frustration most instructors experience when they realize how little their students understand or remember from a semester of charismatic lectures. If not ignored, that frustration leads to reflection on what it means "to teach" and "to learn." Problem-based learning addresses these issues and offers an attractive alternative to traditional education by shifting the focus of education from *what faculty teach* to *what students learn.* Content remains important, but emphasis

shifts more to the process. For those used to lecturing, the trade-offs can intimidate, but the promise of greater student understanding sustains the effort. Fundamentally, adopting PBL requires a transformation of the classroom role of the instructor from a "sage on the stage to a guide on the side" (King, 1993). With that change in perspective comes the commitment to accept the risks and take the time. However, commitment alone is insufficient. Advanced planning is necessary to anticipate pitfalls encountered by blind enthusiasm (McKeachie, 1986; White, 1996a).

Getting Started Ahead of Time

Mentoring

Getting started begins well before the semester begins. Sometimes the idea of transforming a course to one with a PBL format incubates for several years. The change in perspective requires getting used to. Finding others who have experience helps this transition, because few instructors have themselves been taught in a PBL classroom, and it is sometimes difficult to envision how a PBL class operates or to anticipate all the situations one might encounter. Instructors who use PBL have traveled the same path and appreciate the problem. In most cases, they welcome visitors to their classes. Those getting started should take advantage of such opportunities and find a mentor. An occasional coffee break or lunch with others using PBL can help deal with new situations. Most concerns relate to process; thus, colleagues from diverse disciplines can contribute constructively to each other's effective teaching. The University of Delaware PBL website (see electronic resources for PBL at the end of the list of references for this chapter), and related PBL listserver also provide information and a forum for discussion.

Decisions

While circumstances may limit choices, some ways of getting started are easier than others. Occasionally, one might start by creating an entirely new course with a PBL format, but more often, instructors will transform one of their existing lecture-based courses into one that uses PBL. Because existing courses are already built into the curriculum, they have an established content and clientele, and they constitute part of the regular workload. These factors legitimatize the effort. Most faculty choose to make the transition gradually by introducing a problem-based exercise every week or two at first. They also tend to start with smaller classes and courses within a major. Once comfortable with PBL, instructors often transform other courses they teach.

Course Goals and Learning Objectives

Once the decision to transform a course has been made, formulating a list of instructional goals focused on student learning helps subsequent decisions. Examples of such goals can be found elsewhere in this volume. Because PBL addresses behavioral issues in addition to content issues, the course goals probably will change the way a course is structured and conducted. For example, oral and written communication skills or the ability to find and use new resources often become explicit goals that may have been subordinated to content goals without a PBL format. The new priorities lead to new assignments and restructured schedules.

Finding Problems

With the exception of a few disciplines, notably medicine and business, good PBL problems usually do not appear in textbooks. As a consequence, an instructor needs to find problems, modify textbook problems, or write new problems that address the course content goals and learning objectives. The "learning issue matrix" (White, 1996b; White, Chapter 12 of this book) provides a strategy for selecting a set of problems that covers the course content. While having to write problems may be necessary and seem to be a significant barrier, most instructors find writing problems an enjoyable scholarly activity (White, 1995; Duch, Chapter 5 of this book). Furthermore, because of the need, there are outlets for publishing good problems. The *PBL Clearinghouse* and *Case Studies in Science* are two web-based opportunities, while educational journals, such as *Biochemistry and Molecular Biology Education* (see electronic resources for PBL at the end of the list of references for the URLs to these three sites) or the *Journal of College Science Teaching* will accept manuscripts describing PBL problems.

Using the Syllabus to Get Started

Because the syllabus defines a course, it needs to be completed before the first class and should distinguish the new PBL format from the format of previous offerings of the course. Its contents provide a framework for discussing the issues in introducing PBL, while the course goals, noted previously, provide the basis for making decisions relating to these issues. Altman and Cashin (1992) identify the following seven major topics that should be in a syllabus: course information; instructor information; text, readings, and materials; course description and objectives; course calendar and schedule; course policies; and available support services. These will be discussed in turn with respect to decisions associated with getting started with PBL.

Course Information

This includes basic syllabus material, such as course title, course number, prerequisites, credit hours, meeting time, and meeting place. Some of these items will be influenced by a change to a PBL format. For instance, when and where will the class meet? To provide longer time for discussion, it may be useful to have two 75-minute classes per week rather than three 50-minute classes. It may be worth considering nonstandard meeting times, such as 75 minutes on Monday and Friday to distribute time for out-of-class research if this is possible at your institution. The classroom itself is quite important. A room with tables where students can work comfortably in groups is preferable to a room with fixed seating in a tiered auditorium. A room with lots of blackboard space provides opportunities for effective communications within groups.

Instructor Information

As for every course, the syllabus should contain information about who the instructor is and where, how, and when he or she may be contacted. Not only is student communication with the instructor important in a PBL course, but other lines of communication are important and can be established ahead of time. E-mail newsgroups, chat rooms, and electronic class-mailing lists can be used to facilitate student-student and intergroup communication, which can be more important than in a typical class and may need to be structured ahead of time.

Instructor information in a syllabus might include a statement of teaching philosophy that relates to PBL. That information might also accompany a friendly e-mail message to the class during the week before the semester starts. Such a gesture can set a positive tone for the course and let the students know something about the course as well. If the syllabus is on a course website, the message can provide its URL. This also is a good time to get feedback from students that might be helpful in assigning them to groups. If the course involves teaching assistants or tutor-facilitators (Allen & White, 2000, and Chapter 8 of this book), that information can be included with information about the instructor.

Text, Readings, and Materials

Frequently, a PBL format changes the way instructors and students see and use textbooks. A decision that an instructor needs to make is whether to have a text, and if so, does a different text fit the PBL format better than texts used previously. For an advanced course built around problems in which students need to access multiple primary resources, a text may be unnecessary. For a course that uses a PBL format only part of the time to emphasize certain concepts during class time, a textbook is an important reference and may be selected for its encyclopedic character rather than its readability in independent study. Decisions on a textbook may be driven on whether the significant learning issues are (or are not) covered and whether this fits with the course goals.

Depending on the course goals, an instructor may provide supplementary readings in the library or eliminate them in courses where students need to find resources for themselves. With increased use of the Internet and the enormous variability in the quality of websites, some instructors choose to provide a list of Internet sites that provide reliable information. In another approach, instructors direct students to websites that provide guidance in evaluating other websites because students frequently equate an attractive layout with "good" informational quality. If one plans to make greater use of library and Internet resources, the availability to students also must be considered. Not all students have computers, and commuting students can be put at a disadvantage.

Course Description and Objectives

What is the purpose of the course? Where does it fit into the curriculum? How will students change as a result of taking the course? While many of the decisions identified so far appear in a syllabus as statements with little elaboration, the course description is the meat of a syllabus and requires a narrative, particularly if one plans to use PBL. For example, the course goals and learning objectives belong here. Students need to know what they are expected to do and why groups are important. Most certainly, a PBL format will lead to unfamiliar types of assignments, such as generating a concept map as a group. These may be introduced in a syllabus.

If the students entering the course have little or no experience with PBL, the syllabus is the place for the instructor to explain what PBL is. It also is a good place to explain why PBL fits in with the instructor's teaching philosophy and why it is important for student learning. Much of the resistance to PBL by students, particularly in the early weeks of a course, comes from the surprise of doing something unfamiliar and not knowing why the instructor is "doing this to them." As noted earlier, PBL relies on good communication, and it is the instructor's responsibility to discuss teaching philosophy in the syllabus and at the beginning and throughout a course.

Course Calendar and Schedule

The use of a PBL format implies that the instructor values group process and problem-solving abilities. Typical course examinations given during class time

often do not incorporate such values. Consequently, a significant decision is whether or not to schedule out-of-class examinations with relaxed time constraints and incorporate group elements. For example, a three-hour evening examination permits successive individual and group parts (White, 1997). Such an arrangement extracts a cost because in most courses there will be a few students who have conflicting schedules. Furthermore, a room, perhaps the normal classroom, needs to be available and reserved. Many schools require that the dates and times of out-of-class examinations be printed in the registration booklet so that students can arrange their schedules accordingly when they register. This means that the decision for an out-of-class examination needs to be made and approved quite early.

One must decide how often to use a PBL format and incorporate that into the course schedule. Good PBL problems are open-ended and may take more time than anticipated. Students need sufficient time to research, discuss, and come to closure on a problem. Consequently, the schedule and instructor need to be flexible. One way to allow for changes during the semester is to title the schedule as "tentative."

Course Policies

PBL affects many course policies and thus requires decisions. Group progress and group dynamics depend strongly on full participation. Thus, absences and tardiness disrupt a PBL class in ways that would be unimportant in a lecture class. An instructor should have a firm attendance policy, which also is affirmed by group guidelines. In a lecture class, individual students can do quite well and not have to say one word in class during an entire semester. Such silence would undermine the PBL process. There are ways for introverted students to contribute significantly to group process. Ideally, the instructor's policies should be discussed and agreed to by all groups and appropriate consequences specified for noncompliance, for example, some groups may agree to exclude repeat offenders from group portions of examinations.

PBL also affects grading policies. What is the proper balance between individual and group work? How much will peer evaluation contribute to individual grades? How much are process skills valued, and how is that factored into a grade? What constitute criteria that distinguish one level of achievement from another?

Academic honesty creates a dilemma for some students in PBL classes. Throughout their academic career, teachers have discouraged collaboration with other students. Now the rules seem reversed. What constitutes academic dishonesty? What can be shared for credit? These issues need to be discussed and clearly defined in the course policies. Students need to know that they

learn on their own and that there is individual accountability. Working in groups facilitates learning, but it is not a license to use the work of others as one's own.

Available Support Services

Students have access to a wide variety of academic support services. Some of these resources are especially useful for courses using a PBL format, and instructors may decide to set aside time to ensure that their students know about them and can use them. For example, a PBL course often requires students to identify and locate resources that they need. However, many students have only rudimentary skills in exploiting library resources and may need guidance. While they may be familiar with surfing the Internet, they may have little ability to distinguish authoritative information from the biased information available on a myriad of advocacy sites. In most disciplines, there are particular search strategies that are preferred to others. These may be laid out in a syllabus or on a course website. Given these needs, an instructor may arrange for a library tour or a presentation on web resources.

Getting Students Started with PBL

The First Week of Class

Despite all of the advanced preparation, a certain amount of apprehension and self-doubt accompanies the beginning of a first-time PBL class. What if something goes wrong? What if the students don't like it? Imagine a classroom full of students who have spent their entire education in lectures and are seated nicely in rows facing the front of the room. This course will be unfamiliar to them or, if not unfamiliar, something they may have found unpleasant. Will they buy into PBL?

There are many approaches and, as noted earlier, sending an e-mail message to the whole class a week before the semester starts can ease both student and instructor apprehensions about PBL. It is important, however, not to call PBL an "*experiment.*" The students need to know what will be different and why, but they do not wish to be guinea pigs. The introduction could take the form of a lecture—but that may send the wrong message in a PBL course. A successful approach is to initiate group discussions that evolve into a whole-class discussion about the students' prior experiences with groups and why they liked or disliked those experiences. This demonstrates that discussion is expected and that student concerns are heard. In addition, an "ice breaker" exercise often shows in an experiential way what a lecture or discussion

cannot. I have developed the following activity, *Stand and Deliver,* that provides a visceral appreciation of the importance of teacher-to-student, student-to-teacher, and student-to-student communication in learning.

Stand and Deliver

Much of what we do when we lecture is to describe things and create mental images with words. These words have discipline-specific meaning that students sometimes misinterpret or don't understand. The following group activity deals with verbal communication of images. The rules of this "game" are simple.

1. Teacher Selection. Within each group of four or five students, determine who has the birth date closest to today. That person will be the *teacher* for this activity.
2. Lesson Plan. Assemble all of the teachers in the hall outside the classroom and show them a simple geometric figure that they will have to describe orally to their group of "students." The figure should have about three simple components; for example, a square, a triangle, and a circle and of different sizes, in different positions, and overlapping in different ways so that the sizes, relationships, and orientations become important details to communicate.
3. The Lecture. The teachers return to their groups for two minutes while they describe, as accurately as they can, what they saw. The teachers *cannot use hand gestures,* and the students *cannot ask questions* of the teacher or talk among themselves during the "lecture." The students may take notes, but cannot draw pictures yet.
4. Teacher Conference. After the lecture, the teachers leave the room and can discuss the experience among themselves until step 7.
5. Individual Work. Without talking to each other, each student must draw, as closely as he or she can, a copy of the figure described by the teacher. The objective is to be as close to a carbon copy of the original drawing as possible. They have two minutes to do this.
6. Group Work. The members within each group compare their drawings and discuss the differences in an attempt to come to consensus. In five minutes, each group should have a revised consensus drawing to show to their teacher.
7. Teacher Assessment. The teachers return and see what their students have drawn. Groups then can discuss the exercise. At this time, each group receives a photocopy of the original drawing to compare with their drawing.
8. Reflection. Among the questions groups might consider in discussing the implications are: Did everyone in your group draw the same picture? Did subsequent discussion improve the representation? Was the teacher happy with the results? What were your frustrations, if any? Can you make any conclusions?

This activity generates a lot of discussion and raises important questions about how we communicate and the importance of feedback. It also addresses what it means to teach and to learn. Given additional time, groups can discuss how such an assignment might be graded. Clearly, there will be many things going on during the first week of classes, and this is just one idea for getting started.

Keeping Going with PBL

For anyone getting started with PBL, the learning curve is steep. It may seem a bit overwhelming to have to deal with issues of group dynamics, educational psychology, and student learning skills in addition to the subject matter. However, practitioners need not be experts and one need not implement everything at once. The change in perspective that accompanies the adoption of a few PBL exercises in one course usually leads to more and to the transformation of other courses. It also leads to a revitalized interest in education. Once started, it is easy to keep going.

Author Biography

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Altman, H. B., & Cashin, W. E. (1992). *Writing a syllabus.* Idea Paper No. 27, Lawrence, KS: Kansas State University, Center for Faculty Evaluation and Development.

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White, H. B., III. (1996a). Dan tries problem-based learning: A case study. To *Improve the Academy, 15,* 75–91. (also posted at http://www.udel.edu/pbl/dancase3.html)

White, H. B., III. (1996b). Addressing content in problem-based courses: The learning issue matrix. *Biochemical Education, 24* (1): 41–45.

White, H. B., III. (1997). Untimed individual/group exams, problem-based learning. In S. Tobias and J. Raphael (Eds). *The hidden curriculum: Faculty-made tests in science. Part 2. Upper-division courses,* pp. 102–103. New York: Plenum Press.

Electronic Resources for Problem-based Learning

Biochemistry and Molecular Biology Education.
http://www.elsevier.nl/inca/publications/store/6/2/1/2/4/5/

Cases Studies in Science. http://ublib.buffalo.edu/libraries/projects/cases/new.htm

PBL Clearinghouse. https://www.mis3.udel.edu/Pbl

UD PBL: Problem-Based Learning. http://www.udel.edu/pbl/

8

UNDERGRADUATE GROUP FACILITATORS TO MEET THE CHALLENGES OF MULTIPLE CLASSROOM GROUPS

Deborah E. Allen
and Harold B. White, III

Chapter Summary

Problem-based learning (PBL), which emphasizes individual initiative and collaborative classroom groups, may pose novel challenges to students who first encounter it. Undergraduate peer group facilitators help to ease this passive-to-active transition anxiety, and improve the quality of the PBL and group experience. This chapter describes an interdisciplinary program (which includes a university-wide course in Tutorial Methods of Instruction) for preparing undergraduates to function well in this peer group facilitator role.

Why Use Undergraduate Group Facilitators?

As we set out to develop undergraduate problem-based learning (PBL) courses (Allen, Duch, & Groh, 1996; White, 1996), we faced challenges that were similar to those confronted by the early adopters of PBL in the medical

David, T., Patel, L., Budett, K. & Rangachari, P. (1999). *Problem-Based Learning in Medicine : A Practical Guide for Students and Teachers.* The Royal Society of Medicine Press.

Example 2

Intended learning objectives

Students should understand:

- the pathogenesis of meningococcal septicaemia
- the mechanisms of shock
- toxins and inflammatory mediators.

The problem

The problem is a short account of a child who died. The child's name is fictitious.

> ***Rapidly fatal illness***
>
> *John Smythe, aged four, was noted to be unwell and feverish one morning. His mother called the general practitioner who arrived at 10.40. He found that the axillary temperature was 38.6 °C and, when he examined John's chest, he noted some purpuric spots on both arms. The general practitioner decided to send John to hospital for observation and transport by ambulance was arranged. John arrived in the accident and emergency department at 11.55. By the time he arrived, his condition had deteriorated and the purpuric rash was noted to have extended to the trunk and legs. Benzylpenicillin 1 million units was given intravenously at 12.05 but, despite supportive therapy, he rapidly deteriorated and had a cardiorespiratory arrest, from which he could not be revived, at 12.40.*
>
> *Explain the skin lesions and rapid death in terms of the underlying processes.*

Possible discussion points

Below, taken from some actual tutorials using this problem, are listed some examples of the sort of items that could arise at each of the first five steps of the sequence.

- Clarify unfamiliar terms
  'Are purpuric spots the same as petechial spots?'
  'I'm not sure what 'supportive therapy' means.'

- Define the problem(s)

  'What would have been the mechanism of fever?'

  'Does it make any difference where one finds purpuric spots?'

  'What is purpura and why did it occur in this boy?'

  'In pathophysiological terms, why was there such rapid deterioration and death?'

  'What conditions could make a four-year-old boy suddenly become unwell and die so quickly?'

  'Could giving penicillin have contributed to the patient's demise? Could his death have been due to an allergic reaction to penicillin?'

- Possible hypotheses or explanations

  Brief examples of hypotheses or explanations for one or more features of this case that have been offered include:

  'Fever suggests infection.'

  'The purpuric rash suggests a clotting problem.'

  'The illness could have been meningococcal meningitis.'

  'The clotting problem was probably DIC (disseminated intravascular coagulation).'

  'He died because of mismanagement; if the general practitioner had arrived sooner and if John had been sent to hospital more promptly, he would have survived.'

  'The general practitioner should have given him an injection of penicillin before sending him to hospital. This was the critical delay in treatment which caused his death.'

  'It was the penicillin that killed him. He died of an anaphylactic reaction.'

Examples of questions (rather than hypotheses) that might arise during discussion are:

'Why is it that some patients with meningococcal meningitis die, whereas others survive?'

'What is the connection between release of cytokines and shock?'

'Do cytokines mess up the process of clotting?'

'Was it internal bleeding that caused his death?'

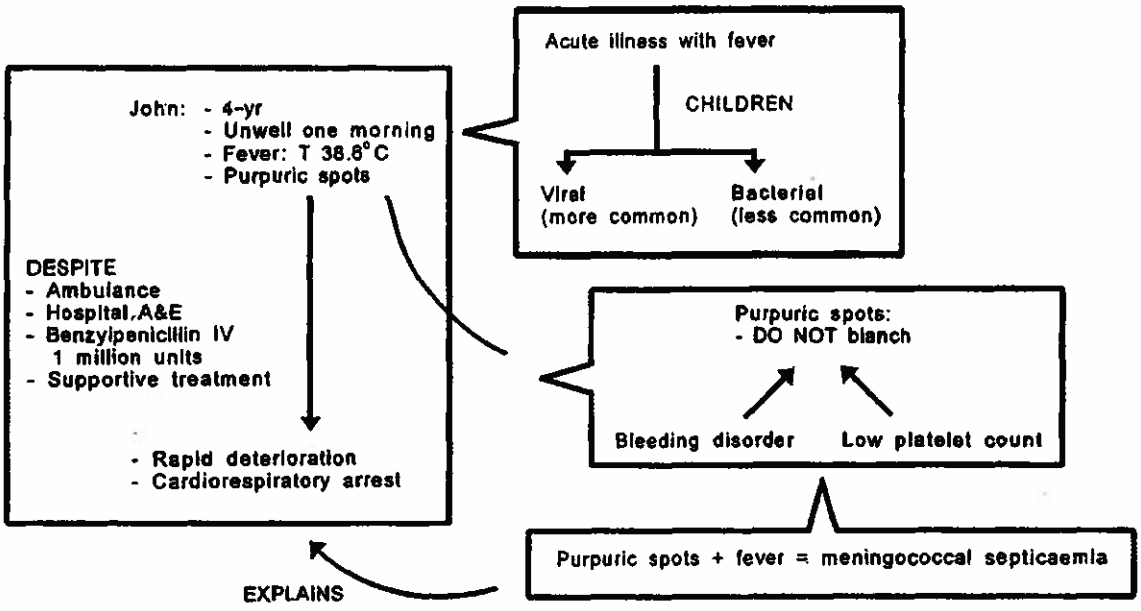
'What could be the connection between purpura and rapid death?'

- Arrange explanations into a tentative solution

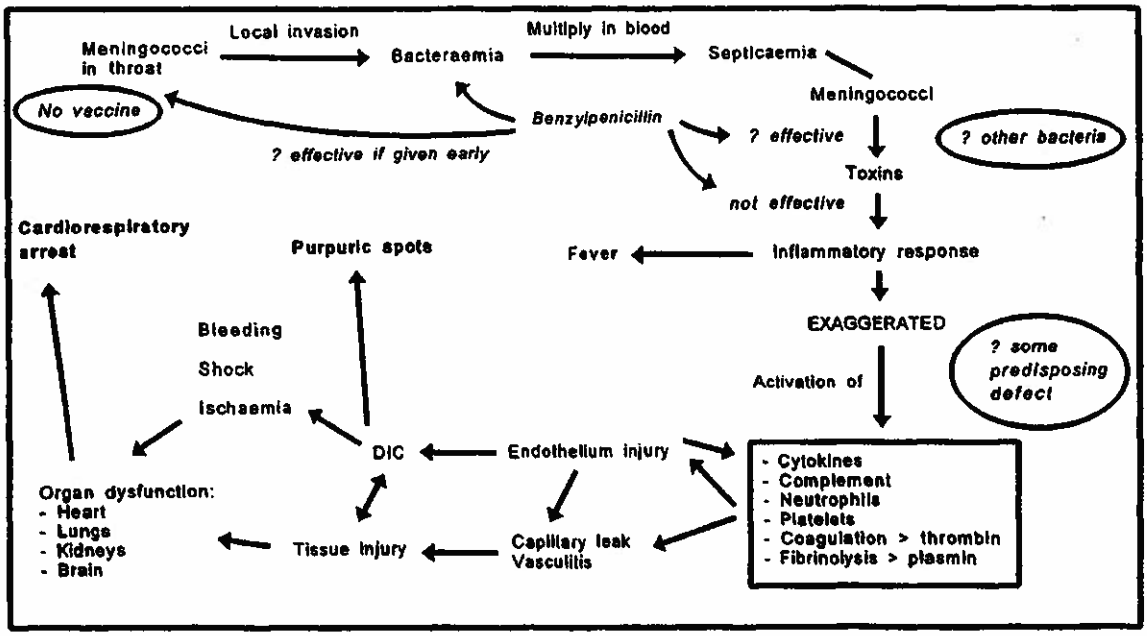
  'He probably had meningococcal meningitis. The bacteria somehow caused an inflammatory response, producing the fever and somehow deranging the clotting, to produce purpura, internal bleeding and shock. The inflammatory

response is probably more severe in some cases than in others. It was severe in this case and that is why he died, despite having treatment.'

Students are likely to start off with relatively simple knowledge frameworks, like the ones below:



As students progress through the discussion, more information should be added and linked with existing knowledge. Knowledge thus constructed will result in frameworks being modified and made more complex:



- Define learning objectives

  'What is special about meningococcus? Why does it cause more serious infections than other bacteria?'

  'Could other infections have produced the same picture, or must this have been meningococcal?'

  'What is the best antibiotic treatment for meningococcal meningitis? What other treatment can/should be given?'

  'What is the pathogenesis of shock and what part is played by cytokines?'

  'What is supportive treatment? Is it just intravenous fluids or can it mean other substances, such as steroids or epinephrine?'

  'What should a general practitioner do if he/she suspects a patient has meningococcal meningitis?'

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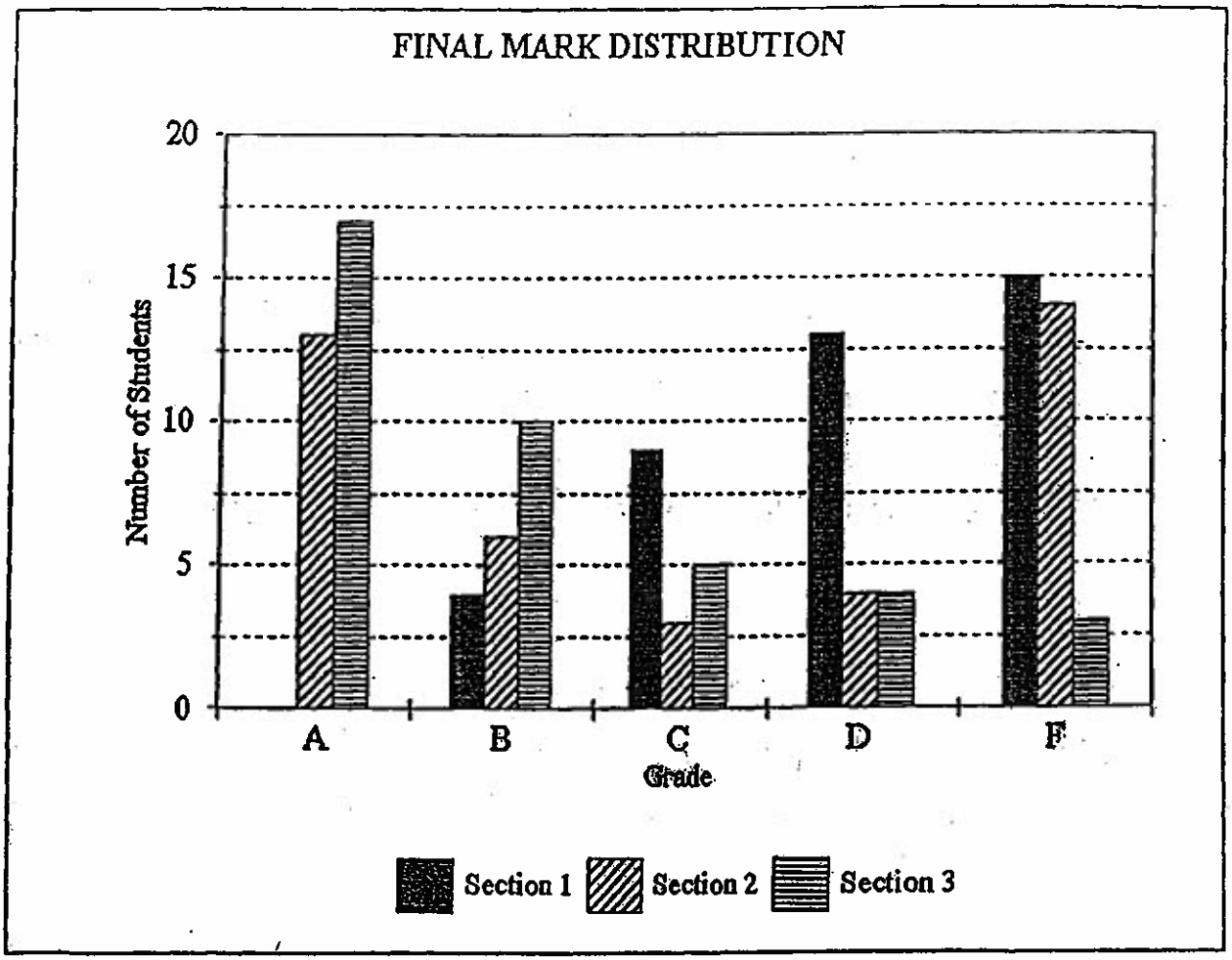
PBL CASE #4: Assessment of Learning

You are a member of the Department Marks Review Committee. This Committee was developed in response to increasing student complaints and the Dean's concern over disparities in marks for different sections of the same course (example from Biology 1A06 below).

As a Committee, your purpose is to suggest some departmental-wide changes in the way grades are assigned; however, you do not want to rush in. First, you want to gather as much information about the assessment of learning as possible.



Mean Grade ± Standard Deviation

Section 1: 53.0 ± 11.9 Section 2: 61.6 ± 23.7 Section 3: 73.8 ± 16.3

i carry your heart with me by E. E. Cummings

i carry your heart with me(i carry it in
my heart)i am never without it(anywhere
i go you go,my dear; and whatever is done
by only me is your doing,my darling)
i fear
no fate(for you are my fate,my sweet)i want
no world(for beautiful you are my world,my true)
and it's you are whatever a moon has always meant
and whatever a sun will always sing is you

here is the deepest secret nobody knows
(here is the root of the root and the bud of the bud
and the sky of the sky of a tree called life;which grows
higher than the soul can hope or mind can hide)
and this is the wonder that's keeping the stars apart

i carry your heart(i carry it in my heart)

What does this mean?

The United States and Jewish Refugees After the Holocaust

In the spring of 1945 the ghastly extent of Nazi atrocities became visible as Allied armies liberated German concentration camps. The haunting scenes of human carcasses stacked in the dumps of Buchenwald, Auschwitz, and Bergen-Belsen morbidly confirmed earlier rumors of fascist brutality.

In July President Harry Truman saw the misery of war firsthand during his trip to Potsdam (outside Berlin) to meet with Stalin and the British. As the presidential motorcade sped along the road from Antwerp to Brussels, Belgium, Adolph Hitler's legacy rolled past the window in a panorama of destruction and horror. Bombed-out homes and factories, a Nazi concentration camp at Breendock, and seemingly endless lines of refugees punctuated the drab panorama. In Brussels the president boarded his plane for the flight to the heart of the defeated Third Reich. Scenes of rubble appeared everywhere. Over the cities of Kassel and Magdeburg, a military aide later wrote, "we could not see a single house that was left standing."

When the president arrived in Germany, he took a two-hour drive that revealed even greater destruction. "Every building we saw was either badly damaged or completely destroyed," an aide reported. "Much more distressing," one advisor told his diary, "was a long procession of old men, women, children, marching in great numbers along the country roads." They were "carrying, pushing or pulling what was left of their belongings," Truman added.

Jewish refugees faced special problems. Several hundred thousand bitter, cynical, and homeless survivors of the Holocaust had escaped the death chambers but languished in concentration camps at war's end. Harried and uprooted, many existed for months after Hitler's death in barbed-wire-enclosed holes, unsanitary barracks, still wearing uniforms taken from dead German soldiers or, worse, Nazi-issued prison outfits.

Fall and winter news from Europe said that many who escaped the Holocaust now faced an unhappy future of more pogroms and discriminations. A new wave of uprooted, the belated victims of prejudice, inundated the already flooded streams of humanity pouring across the continent from Poland to France--tens, hundreds, thousands gushing into U.S. and British hands, drowning hopes that Nazi defeat would purify the Old World. Death, depression, pessimism, stench, hunger, disease, suicide, insanity--like a festering sore the elements of life for surviving Jews marred the joys of victory.

What could President Truman do, if anything, to relieve this misery? Could he bring some of these refugees to the United States? Or send them to other countries? Many of the surviving Jews, tired of mistreatment and impressed with Zionist promises, sought entrance to Palestine. Should Truman support their desires? Many people in that country opposed such moves, and already violence plagued this Holy Land.

[*Twenty-two pages of background to the conflict in Palestine, the rise of the Zionist movement, US policies toward the Middle East, U.S. Refugee policy, British Mandate policies, etc.*]

What to Do?

In 1946 President Truman sought advice from two commissions. How would you advise him? What understanding of this history justifies and explains your advice?

Appendix (This case is done in class as a simulation, with different groups or individuals responsible for researching and playing different groups or individuals, including William H. Stringer; John Lewis; Anglo-American Committee of Inquiry (1946); Lessing J. Rosenwald; Major General John H. Hilldring, assistant secretary of state for occupied areas; Princeton

University philosopher W. T. Stace; Arab leaders, including the king of Saudi Arabia; Loy Henderson and others in the State Department; Paul L. Hanna; A. H. Silver; Stephen Wise; Harry Truman; British diplomats and political leaders; and executives of oil companies with major holdings in the Middle East.

This case is based, in part, on Kenneth R. Bain, *The March to Zion; United States Policy and the Founding of Israel.* College Station: Texas A&M University Press, 1979, and Kenneth R. Bain, *The Last Journey Home: Franklin Roosevelt and the Middle East* (forthcoming).

Source: *The Class Act*, Searle Center for Teaching Excellence, Northwestern University, March 1999. (http://president.scfte.nwu.edu/camar99.html)

A Day in the Life of John Henry, A Traffic Cop

Written by Barbara Duch. 1993. Revised 1995.

At 13:20 on the last friday in September, 1989 a frantic call was received at the local police station. There had been a serious automobile accident at the intersection of Main Street and State Street, with injuries involved. Lt. John Henry arrived at the scene 10 minutes after the phone call and found that two cars had collided at the intersection. In one car, the driver was unconscious and in the other car both driver and one passenger were injured.

After the emergency vehicles transported the injured to the hospital, Lt. Henry's responsibility is to investigate the accident in order to determine whether one of the drivers (or both) are responsible. With the severity of injury in this accident, the investigation is critical because there may be a fatality involved.

What questions does John Henry have to answer in this investigation? What measurements does he need to take? What data should he collect? What other information does he need to record in order to aid the investigation? What physics principles will John Henry need to use in order to help analyze the data and answer his questions?

If two cars moving at right angles to each other collide, in what direction do you expect the cars to be moving after the collision?

What factors will influence the direction and distance traveled after impact?

Go to Page 2 (and sketch), Page 3, Page 4. To to Instructor's Objectives

Online Resources

Accident Reconstruction Resources by Custom Design and Consultation
Links related to Accident Investigation by National Association of Investigative Specialists
Related Links by Texas Association of Accident Reconstruction Specialists
Accident Reconstruction by Renfroe Engineering
Car Resources from the Escape! series on PBS

LIFE ON ICE II

Hotheads

From *Discover* 16(4), 14 (April 1995)
Please see "Hot-Headed Moles in Antarctica," a problem-based learning problem.

April Pazzo was about to call it a day when she noticed that the penquins she was observing seemed strangely agitated. Pazzo, a wildlife biologist, was in Antarctica studying penguins at a remote, poorly explored area along the coast of the Ross Sea. "I was getting ready to release a penguin I had tagged when I heard a lot of squawking," says Pazzo. "When I looked up, the whole flock had sort of stampeded. They were waddling away faster than I'd ever seen them move."

Pazzo waded through the panicked birds to find out what was wrong. She found one penguin that hadn't fled. "It was sinking into the ice as if into quicksand," she says. Somehow the ice beneath the bird had melted; the penguin was waist deep in slush. Pazzo tried to help the struggling penguin. She grabbed its wings and pulled. With a heave she freed the bird. But the penguin wasn't the only thing she hauled from the slush. About a dozen small, hairless pink molelike creatures had clamped their jaws onto the penguin's lower body. Pazzo managed to capture one of the creatures -- the others quickly released their grip and vanished into the slush.

Over the next few months Pazzo caught several of the animals and watched others in the wild. She calls the strange new species hotheaded naked ice borers. "They're repulsive," says Pazzo. Adults are about six inches long, weigh a few ounces, have a very high metabolic rate -- their body temperature is 110 degrees -- and live in labyrinthine tunnels carved in the ice.

Perhaps their most fascinating feature is a bony plate on their forehead. Innumerable blood vessels line the skin covering the plate. The animals radiate tremendous amounts of body heat through their "hot plates," which they use to melt their tunnels in ice and to hunt their favorite prey: penguins.

A pack of ice borers will cluster under a penguin and melt the ice and snow it's standing on. When the hapless bird sinks into the slush, the ice borers attack, dispatching it with bites of their sharp incisors. They then carve it up and carry its flesh back to their burrows, leaving behind only webbed feet, a beak, and some feathers. "They travel through the ice at surprisingly high speeds," says Pazzo, "much faster than a penguin can waddle."

Pazzo's discovery may also help solve a long-standing Antarctic mystery: What happened to the heroic polar explorer Phillipe Poisson, who disappeared in Antarctica without a trace in 1837? "I wouldn't rule out the possibility that a big pack of ice borers got him," says Pazzo. "I've seen what these things do to emporer penguins -- it isn't pretty -- and emporers can be as much as four feet tall. Poisson was about 5 foot 6. To the ice borers, he would have looked like a big penguin."

"http://www.udel.edu/pbl/iceborers.html"
Last updated Jan. 10, 2000.

Connecting Case Characteristics to Educational Goals[1]

Educational Goals	Case Structure	Case Facts	Analytical Method
Develop Concepts	Description of clear problem (straightforward)	Facts clustered to clearly highlight concept	Students can follow a similar "Worked-out example"
Understand Techniques	Short simple problem (straightforward)	Facts clustered to clearly highlight technique	Students can follow a similar "Worked-out example"
Acquire skills in use of techniques	Structured, realistic problem (medium)	Facts relevant, but do not immediately identify the problem	Method to analyse the case is indicated, but not worked out
Acquire skills in analysis of problems	Complex, unstructured slice of life (medium to difficult)	More facts added	No clear signals about what methods the students should use to analyse
Acquire skill in synthesis of action plans	Problem with clear emphasis on action - (medium to difficult)	More facts added	No clear signals about what methods the students should use to analyse
Develop useful attitudes	Complex, unstructured slice of life (difficult)	Still more facts, (some irrelevant facts), can include opinions of characters	No clear signals about what methods the students should use to analyse the problem
Develop mature judgement, wisdom	Complex, unstructured slice of life (difficult)	Still more facts, (some irrelevant facts), can include opinions of characters	No known technique is guaranteed to succeed

[1] Adapted from Erskine, J., Leenders, M. & Mauffette-Leenders, L. *Teaching with Cases* School of Business and Administration, University of Western Ontario, London,1981.

How do you Design a Case?

Plan	
Consider the purpose.	How is the case going to be used? • exam question • individual assignment • group discussion • group project • practice • learn new topics What will students gain?
Consider the objectives.	Keep in mind issues specific to your area of study • Assessment: collects, analyze, interpret data • Planning: form goals, objectives, choose intervention/services for care plan • Implementation: activate care plan • Evaluation: appraise effectiveness of intervention and professional competence Allow students to explore primary areas in your discipline, • Clinical • Education • Administration • Research • Policy • Ethics Match the case to the course objectives and course level .
Consider level of difficulty.	Should the case be straightforward or complex? What level of content/theory should be addressed?
Consider what level of thinking you want from the students. 1. Knowledge/Comprehension 2. Application 3. Critical Thinking: analyze, synthesize, evaluating, recommending	To cultivate high-level thinking: • One course or activity is not sufficient, build in several opportunities. • It takes time, so it is better to build activities into a whole program, so that it can develop over time, through experience with challenging content. • Students should be aware of the expectation.
Prepare	
Imagine situations.	Think of several real situations, then pick the best. • go talk to people: colleagues, clients • examine current events • video clips • government decisions or policies
Find necessary details	Sometimes it is necessary to go and find out details. Students need sufficient background to be able to identify with the situation. • relevant details about people: such as age, gender, culture, socio-economic status • relevant details about the environment (ex. Private, Public) • if appropriate, details about how the problem arose
Consider teaching methods to prepare students.	Will you need workshop, activities or handouts? • Are the students used to this kind of learning? • Do they know the benefits of this kind of learning,

	for them? • Will they be expected to work in groups? • Do they have experience working in groups?
Write	
Choose the point of view.	Usually write the case from the point of view of the decision maker
Choose what facts to include.	Include relevant facts needed to understand the situation and make a decision. • Do not distort real facts, but do disguise real people.
Choose the writing style.	Use the 'active voice' because it is more dynamic, and takes less space. • "She did it." rather than "It was done."
Decide how the case will be delivered.	Will the case be given all at once? Will the case be divided up and given one part at a time?
Decide if you will include any materials.	• Resources (materials, suggested readings, websites) • List of Learning Goals (it may be best to give these after they have worked on the case) • Instructor's Guide: if more than one person is using the case to teach the same thing, it gives the objectives, the main anticipated issues, possible questions
Choose a title.	This will make it easier to refer to the case.
Decide how the student will be assessed and write clear instructions.	How much is it worth in grades? How much time should it take? • Exam: multiple choice or short answer • essay, research summary • presentation, group work
Revise	
Revise.	• Remove unnecessary words or phrases to make the case more clear and exciting, avoid jargon. • Label charts, tables and appendices and identify them in the case. • Make sure that it is clear to the student what is an opinion and what is a fact. • Change any real names and locations. *(see checklist for additional points)*
Present to the students. Revise again!	• You will only know if it is a good case after you have given it to your students!

Adapted by Erika Kustra, McMaster University (2008) from resources including:

Erskine, J., Leenders, M. & Mauffette-Leenders, (1998). *Teaching With Cases.* Richard Ivey School of Business; The University of Western Ontario, London.

Leedners, M. & Erskine ,J. (1978). *Case Research: The Case Writing Process.* School of Business Administration, The University of Western Ontario, London.

Checklist: Evaluate the Effectiveness of a Case

Quality:

- ☐ Can I identify the Objectives?
- ☐ Does the case help meet the Objectives?
- ☐ What issues would I identify? Are they important ones for the students to know?
- ☐ Does it elicit the appropriate content?
- ☐ Is the case useful?
- ☐ Is the case real?
- ☐ Does it elicit the appropriate level of thinking and difficulty ?
- ☐ Will there be issues my students care about?
- ☐ Have I prepared the students appropriately?
- ☐ Am I asking the students to do/produce something meaningful with the case?

Clarity:

- ☐ Can students understand the case?
- ☐ Does the case present information in a logical and meaningful order?
- ☐ Are there logical connections between the sections?
- ☐ Does it contain all the necessary facts and materials?
  - to understand the situation
  - to identify the problem/issues
  - to identify with the characters and environment
  - to make a decision
- ☐ Would I need any additional information to answer this case?
- ☐ Can I remove anything without affecting the understanding of the reader?
- ☐ Is it clear to the student what they must do?
- ☐ Is the method of grading clear?
- ☐ Have I removed all unnecessary words and phrases?
- ☐ Are all real names and locations changed?

Quantity:

- ☐ Is the length of the case reasonable to read in the given time?
- ☐ What are you asking the students to do or to produce?
- ☐ Is the amount of work reasonable for the amount of time?

Erika Kustra, McMaster University, Revised 2008

Continuity:

- ☐ Does it help students meet the approved requirements for the program?
- ☐ If I use this case, what lectures/labs/discussions/activities will I change, add or eliminate in the course?
- ☐ What types of learning resources might be needed for the students to use this case? Are they available?

Polishing:

- ☐ Is the case title appropriate?
- ☐ Is the wording precise and clear?
- ☐ Is it written in the active voice?
- ☐ Check the writing:
  - same tense used throughout (eg. everything in past tense: "She said...")
  - spelling
  - punctuation
  - grammar
- ☐ Are any tables, exhibits, charts, pictures, etc. labelled clearly in consecutive order?
  - example: Exhibit 1 or Appendix A
- ☐ Are headings used to guide reading if the case is long?

Final Revision:

You will only know if it is really a good case *after* you have given it to students!

- ☐ Did the students identify the issues?
- ☐ Did the students learn the objectives?
- ☐ Were there other objectives that should be included?
- ☐ What were the stumbling blocks?
- ☐ Were students led down the wrong path by anything in the case?
- ☐ Was the case to vague, difficult or long?
- ☐ Were the students able to locate useful resources?
- ☐ Was there adequate time?
- ☐ How well did the case fit with other elements of the course?

Sample Case-Based Exam Criteria [1]

Criteria	Comments	Grade
Identification of Issues: • Appropriate Issues • Complete		
Issue Analysis: • Criteria generated to Analyse • Importance of Issues • Causes and Effects • Constraints • Opportunities		
Alternatives Analysis: • Alternatives are suggested • Analysis of Alternatives		
Recommendations: • Legitimacy of decisions • Reasonableness • Feasibility of action/plan		
Logic: • Congruence between analysis and recommendations		
Presentation: • Quality of Language • Appropriate use of Exhibits • Organization of the exam		
FINAL GRADE:		

[1] Adapted from Erskine, J., Leenders, M., Maufette-Leenders, L. Teaching With Cases. Ivey Publishing, University of Western Ontario, London, 1998.

Using Problem Based Learning for Assessment in Large Classes: Triple-Jump

Erika Kustra,
Centre for Leadership in Learning, McMaster University
http://www.glos.ac.uk/ceal/resources/casestudiesactivelearning/activelearningcasestudies/casestudy7.cfm

Context

Course: Biochemistry (~ 1990s)
Instructor: Luis Branda, McMaster University, Professor Emeritus

In a large, required, undergraduate course in Biochemistry (over 300 students), Luis Branda used a variation of Problem Based Learning called the "Triple-Jump". The goal was to engage students in their own learning, in a format that allowed for individual assessment. The skills required included: analyzing a problem; identifying important issues and questions; researching one of the most important issues; summarizing, analyzing and evaluating the literature; communicating findings in writing; and then evaluating the work in the light of new information. As a student who experienced the process, it was one of the first bright lights in my undergraduate experience - introducing me to the excitement of research and searching for my own answers. This is my memory of the process.

Process:

First students experienced the novel triple-jump process as an exercise, and then repeated a new triple-jump for a grade, equivalent to a midterm exam.

Step 1: Class 1 (50 minutes)

1. Each student was given a paper problem, based in Biochemistry. The case was based in the real world and linked to a health issue, such as a sick infant.
2. Individually, students read the problem and tried to identify in writing all the issues and questions elicited by the problem.
3. Students were then asked to identify one of the above issues as the most important issue to solve or understand the problem, and give rationale for the choice. This would be the question that they would research,
4. Students captured their work on paper that allowed two or three copies to be made (such as the paper used to create triplicate forms).
5. Two copies of students' responses were handed in to the teaching assistants, and one copy was kept by the individual student to refer to during research.

Step 2: Research between Classes (1 to 2 nights)

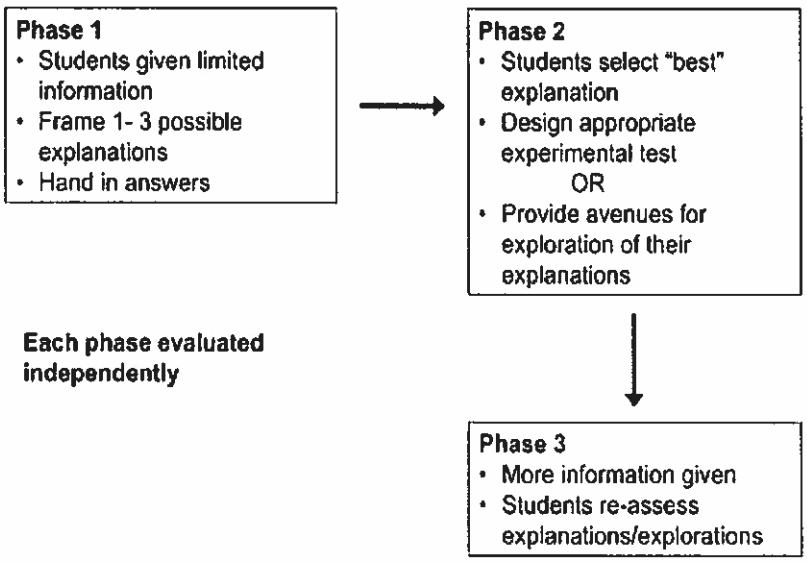
6. Students researched the case to find answers to the issue that they individually identified. Sources such as textbooks and journal articles were encouraged. (The library should be notified in advance about the large group of students.)
7. Collaboration was allowed during the research period.

8. During this time, the teaching assistants and professor grouped the student submissions from Step 1 into similar themes based on the 'important issue' each student identified. A new question related to each theme, with some additional information about the case, was attached to each student's writing. The goal of the new question was to assess the knowledge and thinking gained during the students' research.
9. Possible Alternative: Have one sheet with all of the questions included and instruct students to choose the most relevant question to answer based on their initial 'important issue'. In this case, every student receives the same information, and less time is required for picking up papers. It would not be necessary to return the students writing to them if they were instructed to bring their own copy back to class with them.

Step 3: Class 2 (50 minutes)

10. In the lecture hall, each student's previous writing was arranged alphabetically for pick up.
11. Individually, students answered the question provided by the instructor, based on their research between classes.
12. The students were asked to evaluate their original issue and their current answer in the light of the new information provided in this third step.
13. The final written responses were submitted at the end of the class.

The process is a modified version of the Triple-Jump designed by Rangachari (2002).



Evaluation of the Triple-jump was based on:

a) quality of issues identified
b) rationale behind the selection of the most important issue to research
c) quality of response to the test question (indirectly also a measure of the quality of research and analysis of literature findings)
d) ability to evaluate your own work.

Instructor Preparation:

a) Write an initial case, possible follow-up questions and additional information.
b) Prepare a rubric for grading the responses.
c) Notify the librarians and ensure that there are appropriate resources available and they are prepared for a large number of students.
d) Arrange for triplicate paper for the students to write their responses.
e) Coordinate with TAs to sort the student responses into themes based on the 'important issue' they identified.
f) Refine test questions for each of the themes (my guess is that there would be ~5 common themes and a few outliers, and most questions could be written in advanced based on expected responses). With help of TAs, attach the questions to each student's paper (using different coloured paper for each question would help make it easier to identify themes later).
g) Separate the duplicates of each student's responses to keep one version and return one version. Organize papers alphabetically for students to pick up in class.
h) Explain marking rubric to TAs for the written responses. The actual time to grade the papers would probably be about the same as an exam with short answers.

The process of the large class triple-jump was effective from the perspective of students, in that it was memorable, and appeared more connected to real life. Anecdotally, 20 years later, students I have spoken to still remember the experience, the process and some of the content they learned.

For an alternative variation on a triple-jump, please see: http://www.bambed.org/cgi/content/full/30/1/57

Relevant References

Rangachari, P. K. (2002) The TRIPSE: A Process-oriented Evaluation for Problem-based Learning Courses in Basic Sciences, Biochemistry and Molecular Biology Education, 30 (1), 57-60.

This case study is available as a pdf Using Problem Based Learning for Assessment in Large Classes: Triple-Jump (36Kb Adobe PDF)

27/11/2007

Additional Resources

Useful Links for PBL

McMaster University

Tutor's Guide to PBL (available as a pdf)
Practical guide, definition, process, roles, problems
http://www-fhs.mcmaster.ca/facdev/documents/tutorPBL.pdf

Tutorial McBloopers
Step-by-Step description of process
www-fhs.mcmaster.ca/facdev/documents/tutorialmcbloopsguidefinaljune.pdf

The problem-based learning tutor: Teacher? Facilitator? Evaluator?
http://fhs.mcmaster.ca/facdev/documents/The%20ProblemBased%20Tutor.pdf

Inquiry and PBL links
http://www.mcmaster.ca/cll/inquiry/inquiry.resources.htm

Writing Problems by Rangachari
http://www.fhs.mcmaster.ca/pbls/writing/

Using PBL in Large Classes by Don Woods
http://chemeng.mcmaster.ca/pbl/pbl.htm

Preparing for PBL Handbook by Don Woods
http://chemeng.mcmaster.ca/pbl/pblbook.pdf

PBL Links and Online resources
http://www.udel.edu/pbl/
http://cte.umdnj.edu/active_learning/active_pbl.cfm

University of Queens

Developing a Course
http://www.queensu.ca/ctl/goodpractice/problem/course.html
Handbook: Useful and practical
http://meds.queensu.ca/pbl/assets/pblhndbk2009.pdf

Dublin Institute of Technology

PBL in Physics and with E-Resources
http://physics.dit.ie/programmes/pbl.html

Useful Books on PBL

The Power of Problem-Based Learning

Barbara Duch, Susan Groh, Deborah Allen (Delaware)

- This book has a lot of practical information, useful for getting started. However, I find that their examples of problems are very confined and overly structured, which leaves less room for the students to be self-directed.

Problem-based Learning: How to Gain the Most from PBL

Donald R. Woods

- Don was in Chemical Engineering, McMaster and also worked closely with Nursing and other departments, so the techniques are adaptable to different disciplines.
- This book is helpful for students and faculty starting out –it has helpful tools to guide students, especially if they will be in small tutorless groups.

Problem-based Learning: Resource to gain the most from PBL

Donald R. Woods

- This book has useful resources once you are doing PBL.

Problem-based Learning: Helping your students gain the most from PBL

Donald R. Woods

- This book has useful resources once you are doing PBL.

Problem-Based Learning in Medicine: A Practical Guide for Students and Teachers

Tim David, Leena Patel, Keith Burdett, Patangi Rangachari

- Rangachari (Chari) is a faculty member at McMaster who was one of the early users of PBL in the McMaster Medical school and in graduate Health Sciences.

The Challenge of Problem-Based Learning 2nd edition

David Boud and Grahame Feletti

- This book is referenced quite often in the PBL literature.

Problem-based Learning in Higher Education: Untold Stories

Maggi Savin-Baden

- Helps to present PBL as a method of teaching that involves a mind-shift in thinking about teaching and learning.

The Bases of Competence: Skills for Lifelong Learning and Employability

Frederick Evers, James Rush, Iris Berdrow

- Fred is at Guelph University, Ontario and did research on the skills university graduates need. Although PBL is not specifically mentioned in the book – the research supports many of the skills that are developed through PBL and may be helpful to departments trying to make a case for using PBL or similar methods.

Problem-Based Learning: Educational Innovation Across Disciplines

Tan Oon Seng, Penny Little, Hee Soo Yin, Jane Conway

- This book includes chapters from many different authors from different disciplines and countries, so a diverse view of PBL. It includes a chapter by Don Woods "Helping your students gain the most from PBL", it also includes faculty and student reactions to PBL, and developing a PBL curriculum.

Problem-Based Learning: Case studies, experience and practice

Peter Schwartz, Steward Mennin, Graham Webb

- These are a series of cases told by real faculty who have used PBL to bring out issues and problems in using PBL. It is set up so that you can read as if you are doing the case.

Journal Articles

Problem-Based Learning and Medical Education Forty Years On A Review of Its Effects on Knowledge and Clinical Performance
Alan J. Neville
McMaster University, Faculty of Health Sciences, Hamilton, Ont., Canada
Med Princ Pract 2009;18:1-9 (DOI: 10.1159/000163038)

Effects of Problem-Based Learning: A Meta-Analysis From the Angle of Assessment
Review of Educational Research Spring 2005 75: 27-61, doi:10.3102/00346543075001027
David Gijbels, Filip Dochy, Piet Van den Bossche, and Mien Segers

The effects of problem-based learning during medical school on physician competency: a systematic review. CMAJ. 2008 Jan 1;178(1):34-41.
Koh GC, Khoo HE, Wong ML, Koh D.

Problem-based learning makes a difference. But why?
Norman, Geoffrey, PhD
CMAJ 2008 178: 61-62