

Preparing for PBL

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Preparing for PBL

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Preface

Dec 2006

PBL is the best thing since sliced bread!

With the success of the method has come a spin off of all kinds of variations on the theme. Indeed, many seem to have renamed what they used to do PBL because they use “problems”. That’s OK. Some use problems to synthesize previous knowledge. This is characteristic of engineering design projects and has led to the term “project based learning”.

This book is not about problem-based synthesis; this book is not about primarily the use of problems. This book is about *small group, self-directed, interdependent, self assessed problem based learning*. The key features are that a) students learn material on a need to know basis and b) students are empowered with most of the learning activities: having been given a problem, they identify pertinent learning goals, learn and teach each other the knowledge and skills, use the new knowledge to solve the initial problem and elaborate the new knowledge.

The biggest difficulties faced in implementing this form of PBL seem to be:

- the mistaken attitude that teachers just pose a problem and then wonderful things happen.
- the mistaken attitude that students can’t learn a subject correctly on their own; “I need to lecture them first and then pose the problem”.
- the mistaken attitude that students will enthusiastically embrace this approach; teachers fail to prepare students well for the transition.

Small group, self-directed, interdependent, self assessed problem based learning was formally introduced as a learning option by McMaster Medical School in the late 1960s. But in emulating this model, some fail to acknowledge some of the conditions that made their approach so successful. This include that in the McMaster medical school program:

- students were mature; they had already completed at least three years of university - yet we are considering using it with students in year 1 university; at least three years younger.
- each group of five to six students had a trained faculty member as tutor - yet we may provide very little training for the tutor and, in many instances, are forced to have one faculty for a group of three to ten groups.
- students seeking admission **wanted** to use this new form of learning; they were ready for learning environments different from the traditional lecture - yet we are considering using this approach with students who really prefer the lectures and don’t want the unfamiliar.
- five criteria were used for admission into the MD program at McMaster: marks, letters of recommendation, personal essay on why the applicant wanted to be an MD, a personal interview and demonstrated skill in the PBL process (especially problem solving, interpersonal skills and group process) through participation in the simulated tutorial.

Most don’t realize that the students entering the Medical school program had these five unique characteristics. I think it is important that we realize that part of the success of PBL is because these McMaster medical school students possessed these characteristics. When we started PBL in Chemical Engineering in 1982 we put in place training elements to acquire the five elements medical students had. This helped our students get ready for PBL. Furthermore, we had to develop methods, especially related to assessment, that would allow us to work with tutorless groups.

In this book we share our experience.

I thank many for their feedback and help. In particular thanks to Lynda Wee, CapitaLand, Singapore, Andy Hrymak, Heather Sheardown, Gord Slater and Lynn Falkiner, Chemical Engineering Department, McMaster University and my students in the program at McMaster University

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**1. What is PBL? How to select a PBI version
that works for you: workshop #1.**

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1. What is PBL?

Activity 1:

The time I really learn a subject is when I _____

When a student asks “Why are we learning this?” do you ever have to say “Trust me, you’ll need this later.” _____

Characteristics of PBL:

- “Just in time” learning: Learn information/skills/attitudes to “solve a problem”
- Problem posed first (before the students have learned anything)
- Students empowered with selecting learning goals, resources, assessment.
- Work cooperatively in small groups (with or without a tutor present in each group).
- Teacher? maintain standards, “Guide on the side not sage on the stage,” monitors the process, (like a design project).
- Students actively engaged in the learning process; students **teach** each other.

2. Why select PBL? The claims

- Improved learning (active, coop, freedom to select, ownership, prompt feedback, learning styles)
 - Tricky: depends on exams.
 - Same or Better knowledge acquisition/understand
 - Common exam: lecture = PBL for knowledge. [UDeI]
 - Physics: pre-post gains Force Concepts inventory:

lecture	0.23	[UDeI]
active learn	0.48	[Hake]
PBL	0.45 - 0.65	[UDeI]

 - Medical NBME I: Slightly less but using multiple choice of primarily memorized knowledge

- Less coverage of subject knowledge
 - True: That's because we include skills and attitude development. 80% "time" to cover material because 20% on process activities.
 - Focus on core fundamentals in each course; eliminate the 20% "nice" stuff.
 - Not a problem from ChE recruiters or alumni; indeed say they are better prepared

- Prefer deep learning
 - Yes. Proven: PBL promotes deep; lectures promote rote and surface approach

- Better learning environment
 - Yes, Ramsden/ Entwistle CPQ [McMaster, UDeI]
 - PBL 35 to 45
 - lecture: 15 to 22
 - mix: 22 to 35

- Easier for recall of knowledge in professional practice:
 - Should but No published evidence other than the "diver" experiment. Divers memorized nonsense lists of words under water and on land; then tested under water and on land. Recall best where memorized.

- Learn lifelong learning skills
 - Yes, Perry, resources used, alumni

- Learn problem solving, team skills etc.
 - No, **opportunity** to develop.
 - Evidence of more empathetic and whole person MDs

- Develops self confidence
 - Yes, anecdotal

3. Experiencing PBL

Case 3: Letter from the Director Your Director has just returned from a conference on PBL. The Director asks you to convert your course to the PBL format

Activity: In small group of 5 or 6, with chair _____; reporter _____, brainstorm the issues this case raises, and prioritize the issues: criterion: what do you want to gain from this workshop in the context of the issues raised.

My role is Questionnaire (MRIQ) ©copyright Donald R. Woods June 1997

The following 18 items are arranged with options (a and b or a,b and c). Each option represents a preference you may or may not hold. Rate your preferences for each item by giving a score from 0 to 5. 0 means you strongly disagree and strongly agree with the other option. 5 Means you strongly agree and strongly disagree with the other option. The scores for a and b, or a, b and c MUST ADD UP to 5 (0 and 5, 1 and 4, 2 and 3. Etc..) Place your rating in the box 'R' next too the statement.

I think my role as a teacher is....

Statement	R	Statement	R
1a. I have a basic conviction that I can make a difference		1b People come to me with basic attitudes and won't change-	
2a. My role is to maintain high standards and fail those who do not make the standards.		2b. My role is to help each succeed and make the most of his/her abilities.	
3a. My role is to uncover material so that students understand.		3b. My role is to cover the material in the curriculum.	
4a. My role is to make learning fun.		4b. Learning is serious business. My role is to be well prepared.	
5a. My responsibility is to teach subjects.		5b. My responsibility is to teach people	
6a. Students must grow personally as well as intellectually		6b. The sole purpose of university is intellectual growth	
7a. Teaching, research, consulting are all opportunities to help others learn. The only difference is the client and the "class size". Teaching and research are a seamless continuum of learning.		7b. Teaching is the burden I must bear to allow me to do research	
		7c. Research is the burden I must bear to allow me to teach in university.	
8a. Teaching and learning are a two-way responsibility If students fail it is partly my fault.		8b. Learning is one-way; I do my thing, and it's up to the students to learn.	
9a. If students understand my presentation, they will automatically remember the material. Learning is rote memorisation and recall of facts.		9b. Understanding is not remembering. Students and I need opportunities to see new concepts in perspective to understand their limitations and to reach conclusions. Learning is active, independent and self-directed	
10a. Students should learn knowledge and the processes for working with that knowledge. Knowledge cannot be separated from thinking.		10b. All students need to learn in college is knowledge.	
11a. The development of values is an integral part of my instructional plan. Values play a significant role in my student's future success.		11b. The development of values is the responsibility of the home and/or the religious component of the student's life. You can't measure "value" development; therefore, it is inappropriate to include this area in one's goals.	
12 a. Students should self-assess. My role is to ensure that the assessment process used by the students is valid. I consider the goals,		12b. Assessment of students is my responsibility. I create and mark all the exams that are used to measure the quality of student learning.	

criteria and the evidence.

I think my role as a teacher is		
---------------------------------------	--	--

Statement	R	Statement	R
13a. My role is to design the whole learning process. Students just have to follow my design.		13b. My role is to empower students with all elements in the learning process: goals, choice of text, assessment...	
14a. I am a resource to help students learn; students have the principal responsibility for making and carrying out their own plans.		14b. I am the source of knowledge. I have the advanced training to be shared with them.	
15a. My role is to help students with academic and intellectual issues. It's not my responsibility to get involved with their personal and social life.		15b. My role is to help students with academic and intellectual issues and to help them with personal problems	
		15c. My role is to help students with academic and intellectual issues and to informally socialise and attend student events	
16a. I prepare the detailed learning objectives, the assessment criteria but publish general guidelines for the students; to do otherwise provides too much detail; it's overwhelming for the students.		16b. I publish detailed learning objectives and assessment criteria.	
		16c. Students should prepare detailed learning objectives and assessment criteria. I monitor the process to ensure the standards are met.	
17a. My role is to help them solve problems similar to those they will encounter in professional practice.		17b. My role is to ensure that they know the fundamentals. I use problems that help develop and test that understanding.	
18a. I teach new knowledge. My role is to present well organized explanations expressed to match the student's learning style.		18b. All new knowledge bears some relationship to past. My role is to activate the past knowledge and help students see the relationship between the new and the old.	

A.^{1,2,6,9}

1a _____	1b. _____
5b _____	5a. _____
6a _____	6b _____
10a _____	10b _____
11a _____	11b _____
15b+c _____	15a _____
TOTAL _____	_____

B.^{1,9}

2b _____	2a _____
16b+c _____	16a _____
TOTAL _____	_____

C.^{2,3,6}

9b _____	9a _____
10a _____	10b _____
17a _____	17b _____
TOTAL _____	_____

D.^{2,3,6}

3a _____	3b _____
8a _____	8b _____
9b _____	9a _____
10a _____	10b _____
14a _____	14b _____
16b+c _____	16a _____
17a _____	17b _____
18b _____	18a _____
TOTAL _____	_____

E.^{2,6,7,9}

12a _____	12b. _____
13b _____	13a _____
14a _____	14b _____
16c _____	16a+b _____
TOTAL _____	_____

F.^{2,6,8,9}

16b+c _____	16a _____
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Reflections:

4. Issues related to selecting a form of PBL

Your comfort zone: Complete MRIQ

- A: _____ scale 0 to 30; 23.7 with standard deviation of 3.6
- B: _____ scale 0 to 10; 7.5 with standard deviation of 2.0.
- C: _____ scale 0 to 15; 12.0 with standard deviation of 1.9.
- D: _____ scale 0 to 40; 29.4 with standard deviation of 5.6
- E: _____ scale 0 to 30; 10.3 with standard deviation of 3.5.
- F: _____ scale 0 to 5; 3.7 with standard deviation of 1.6.

5. Background for selecting a form of PBL

Reminder: On improving Learning: What educational research tells us: (Chickering & Gamson + others)

	already do this	will try	possible	not for me
1. active not passive	0	0	0	0
2. cooperative not competitive	0	0	0	0
3. quality of teacher-learner interaction	0	0	0	0
4. provide prompt feedback	0	0	0	0
5. time on task	0	0	0	0
6. environment expects success	0	0	0	0
7. account for personal learn style	0	0	0	0
8. assessment owned by students	0	0	0	0
9. published goals/criteria (about 30 - 60 per course)	0	0	0	0
10. attention span = 20 min	0	0	0	0
11. wait time before answering 20 s	0	0	0	0
12. knowledge/ skills/ attitude	0	0	0	0
13. high quality <i>social</i> environment	0	0	0	0
14. use Bloom's taxonomy	0	0	0	0
15. evaluate what you do	0	0	0	0

Background:

Straight lecturing is the least effective way to improve student learning. Here is the evidence.

1. Dale's (1967) cone of learning relates our ability to recall to the type of learning environment:
 - Dale suggests that we tend to remember
 - 10 to 50%** from "passive" involvement in the learning process (about 10% from what we read; 20% of what we hear; 30% of what we see; 50% of what we hear and see)
 - 70 and 90%** by "active" involvement (we remember about 70% of what we say and 90% of what we say and do).
2. Students in learning environments where lecturing dominates become more "rote learners"; students learning in PBL or cooperative learning environments become more "deep learners".

So if I currently use straight lectures, what might I do? Simple ways to change from straight lecturing to more effective learning environments include:

1. Use active not passive
2. Use cooperation not competition
3. Provide prompt feedback about student performance

4. Empower the students with parts of the learning process.

5.1. Details about how to actively engage students in the learning process

1. Individuals write reflections (2 min) then discuss with neighbour (90 sec)
2. "Turn to your neighbour and say.. Did you understand that?" .. Summarize what's happened so far?"
.... Do you believe that?" .. The key point so far is..." ... A practical application of this stuff is...." or small group. [Described in Chapter 3.]
3. "Turn to a neighbour and compare or rework notes.
4. Talk Aloud Pairs Problem Solve, TAPPS.
5. Students prepare prompt for class discussion.
6. Students present.
7. Marks for participation.
8. Form a line (take a stand): discuss.
9. Discussion diads or groups.
10. Mass discussion between large collection of students.
11. Students pose problems and discuss.
12. Socratic discussion.
13. Teacher-directed brainstorming/discussion.
14. Socratic or teacher-directed Problem Solving with teacher uncovering information after students have done the task.
15. Socratic "learning".
16. Brainstorm: collect ideas without discussion
17. Bidwell's "quesdiscussion" where brainstorm questions the situation poses
18. Rounds: circle with each 30 s
19. Demo group with substitution
20. Demo group
21. Use Osterman feedback lecture: described in Chapter 3
22. Projects-report; displays, exhibitions
23. Cooperative learning in-class
24. Cooperative learning; mentor groups
25. Cooperative learning: 1 Stay and 3 Stray
26. Cooperative learning: Student peer teach/assess
27. Cooperative learning: Jigsaw:
28. Problem-based Learning
29. Structured controversy
30. Workshops

5.2. Details about how to use cooperative not competitive environments

Positive interdependence:

1. Teacher create environment to promote.
2. Require "norms" meetings.
3. Use contracts for expectations.

Consider various forms of face-to-face cooperative groups:

4. Set up **Informal groups**: students stay in groups 2 to 10 min as diads, triads; teacher gives explicit, precise instructions; require groups to produce a product. This could be Active learning, Table 15-1, items #1 to 4, 9, 19- 21: "Turn to a neighbour..." through to Osterman Feedback Lecture.
5. Set up **Formal cooperative groups**: students stay in groups 2 to 4 weeks; teacher sets the objectives, decides who is in group, explains task & goals, monitors effectiveness, assesses. This happens often in lab groups.
6. Set up **Formal self-directed learning groups**: students stay in groups 10 to 12 weeks; students sets learning objectives that are monitored by teacher, students research and teach each other the subject knowledge. Use **Problem-based Learning**
7. Set up **Projects groups**: students stay together 1 year.
8. Set up **Base cooperative groups**: students stay in groups 1 semester, year, four years. They provide informal support, encourage & assist each other in completing assignments and in succeeding.

Individual accountability:

9. Report/assess: (for options 4-7) the teacher randomly select the individual who will complete the task on behalf of the group: that individual mark for that work is given to all group members. For example, assign a number to each group member and roll a dice [draw a number from a hat] to identify the group's representative.
10. Report/assess: (for options 5-7) as in #9, but the students select the individual, subject to the constraint that for the five tasks being assessed, each group member is selected once and only once.
11. Report/assess: (for options 4-7) teacher publishes a list of those who will represent the group. That individual's mark is the mark of the group.
12. Report/assess: (for options 4-7) all individuals do a task; all will receive the arithmetic average of the individual's marks for the group.
13. Report/assess: (for options 4-7) group provides a single response. All members receive the same mark for task. Individuals report accountability through peer and self-assessment of "contribution".
14. Report/assess: (for options 4-7) group provides a single response. All members receive two marks: the same mark for the response plus a peer/team leader response that notes "individual's contribution".
15. Report/assess: (for options 4-7) individuals do task and get individual mark. Students receive written feedback from peers about their cooperative contribution. Each submits a reflective journal report discussing that feedback and receive individual mark for collaborative effort and skill.
16. Report/assess: (for option 8) twice a year the group reports progress via a poster about their approach; mark for the poster is added for 5% to marks of group members in some identified course.

Positive attitude

17. Use Perry's model and reflection

5.3. Details of how to provide prompt feedback:

1. You mark fewer: fewer total;
2. You mark fewer: spaced: 1/3 then 1/3; then 1/3.
3. You mark fewer: sampling: mark 3 out of 5.
4. You mark less: single cover page summary.
5. You mark structured: format student presentation for ease in marking.
6. You mark structured: format for marking/feedback.

Use peer or self

7. Peer/self: mark assignments in-class with teacher-facilitated.
8. Peer/self: in-class diad.
9. Peer/self: in-class triad.
10. Peer/self: in-class feedback.

11. Use group reports with ratings.

Use cooperative learning groups:

12. You mark fewer: cooperative: group's mark is result of individual effort via random selection or other means.
13. You mark fewer: cooperative group work; mark group.
14. You mark fewer: cooperative group, one person is responsible for the assignment; completes it and peers in group mark and give feedback so that it can be improved before it formally gets submitted to you.
15. Use PBL.

5.4. Details of how to empower students with parts of the learning process

1. Teacher can assign all the problems in the text for homework and then the exam is a selected set from the problems. Students organize selves so that all of the problems are worked and handed in to be marked. Open book exam.

Students can:

2. Set learning goals.
3. Set criteria.
4. Select pertinent resources: people, books, articles.
5. Select type of evidence to show achievement toward goals.
6. Decide on the weighting for different parts of the evidence toward the “final” grade. *Example, best of a 60/40 split between term work and final exam or contract for a percentage between 20 and 80 %.*
7. Self-assess based on teacher’s goals, criteria and forms of evidence.
8. Create goals, criteria, forms of evidence and assess “participation”.
9. Submit “first two questions for the final”; share copies and answers with all class members. Teacher selects two. Open book exam.
10. Create test questions; questions given to another group; students mark, teacher monitors.
11. Create the exam. Teacher marks.
12. Peer assess.
13. Do the whole task: goals, criteria, evidence, assess. Teacher validates the process.
14. Use PBL.

6. Select an option that suits you: see also Decisions

1. No PBL: improve learning:

- a. know their names; call them by name.
- b. use “ombudspeople”: class representatives who tell you how the teaching-learning is going.
- c. limit teacher talk to 20 min; then have some activity. ex “Turn to a neighbour and...”
- d. communicate to them that you *expect them to succeed*.
- e. explain why you are doing this.

2. No PBL but willing to empower them with part of the assessment:

Do #1 and.. let them submit questions (and answers) from which you select 2 or 3 to put directly on the exam.

3. Comfortable lecturing: Do #1 and.. pose a problem first, then lecture, then return and use the knowledge to solve the problem.

4. Comfortable with group work: Do #2, pose the problem and ask groups to list “things they need to know to solve this problem”, list these, then lecture on their learning needs, use the knowledge to solve the problem.

5. PBL for 3 weeks of your course.

6. PBL for a full course

7. PBL for all courses in the program

7. Possible Issues when you implement PBL: (suggested answers in article called “Helping Your Students Gain the Most from PBL: Linda’s complaint”)

Teachers ready?

Students ready?

Created an environment where you will succeed

Appropriate version of PBL used: 5 -6 groups of students, 75 minute sessions instead of three 60 min/ week

PBL well -designed? you know the reason for selecting: active, coop, prompt feedback, expect success, student ownership.

Students accountable?

Lifelong learning developed?

Problems well crafted?
 Process skills applied, extended?
 Assessment done astutely?

8. How to create problems

Example

- Case 6 Paul’s decision

Context: Lifelong learning course to first year students at City University of Hong Kong

Target Objectives:

- Setting priorities
- Managing time
- Budgeting time
- Clearer understanding of the expectations in university for time to study
- Long and short term planning
- Procrastination
- Learning to say No!

Paul’s decision (Ed Ko, City University of Hong Kong)

Paul has been persuaded by his friends to run for a position on the Departmental Society. He really would like to, but he is afraid that doing so might take time away from his other activities. He is already on the university swimming team and has to work five hours a week in order to earn some money to pay back his credit card loans. With six courses that he is taking this semester, he feels that he is constantly behind in his work.

8. How to create problems: criteria for effective cases or scenarios:

About the goals:

1. the chosen learning goals achievable. For single courses (for example in hybrid or conventional programs) about 3 to 5 hours of study for an individual student; about 6 to 10 objectives for a group of 6 students so that each will research/teach the others.
2. the learning outcomes are consistent with the stage of development and builds on and activates prior knowledge.
3. goals integrate knowledge, skills and attitudes across subjects and disciplines.

About the scenario created. (can be a single scenario, or you could build a sequence of scenarios but each would expect the same 3 to 5 hours of student study)

4. the scenario contains “cues” that will trigger the desired search for learning objectives; the learning outcomes expected by the teacher are identified correctly by the students.
5. the scenario includes an appropriate level of complexity.
6. the scenario allows an openness.
7. the scenario is motivational and relevant.
8. the scenario is similar to one we might encounter in professional practice; (for example, in Engineering this might include rating, debottlenecking, design, trouble shooting, labour relationships, team work, public, monitoring compliance with legislative regulations).
9. promotes student activity.
10. any data given should be raw data (like we encounter in practice).
11. the scenario identifies the context, gives a concrete scenario and clearly identifies the expected task without spelling out specifics.

9. Some options for assessment of knowledge learned.

- Student summary of the quality of knowledge learned.
- Group solution to the problem.

- Individual concept maps of the knowledge.
- Individual Test and Exams of the knowledge, TETK. created by teacher, peers, groups, individuals, self.
- Individual teach notes and learning contract.
- Peer assessment of the quality of the knowledge brought to the teaching task.

Assessment of process skills: see series of papers in Chemical Engineering Education “Assessing problem solving skills”, “Assessing team skills”, “Assessing lifelong learning skills.”

10. Developing the process skills see <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL for overview and click on MPS for details. see also paper PBL: Decisions for Planning and Action: why? when? who? where? what? how? see also the workshops given in Woods “PBL” Resources to gain the most from PBL” and “Large Class” workshop.

11. Perry’s check on student attitude; grieving process for students and for you

12. Plan for Success!!! students ready? teachers ready? see Woods, “PBL: how to gain the most from PBL” Chapt 1 and PBL: Decisions with Perry inventory (topic 12) and My Role Is Questionnaire (Topic 5).

13. Practical downsides and how to solve them

Both students and teachers must value the “process skills” and “lifelong learning skills”. PBL must be seen as being more than learning subject knowledge! Structure is needed on your part and careful preparation of the students and their attitudes is important; not all students will embrace this approach nor gain the same amount from the experience. Students self report that the goals meeting is the most difficult.

Feedback for PBL/SDL a120

Feedback for interdependent, self-directed learning Form 3601

Feedback to _____ for Unit ____ Date _____
 Present & on time: Present but late by ____ min. Absent

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these.	A few but major omissions.		Most of these.		All of these.
O _____	O _____	O _____	O _____	O _____	O _____
1	2	3	4	5	6
					7

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these.	A few but major omissions.		Most of these.		All of these.
O _____	O _____	O _____	O _____	O _____	O _____

Followup: from this presentation I will have to:

Must study subject on my own; I learned nothing from your presentation.	Major self-study needed. I have some starting references from your presentation.	Some self-study of the basics.	No self-study of the basics. I want to reflect about the ideas.
O _____	O _____	O _____	O _____

Strengths

Areas to Improve on

from D.R. Woods, "How to Gain the Most from PBL," (1994)

Feedback from the Goals Meeting

Situation\$1

Issues

Number identified: 1 2 3 4 5 6 7 >7

Agreement with tutor <50% 50% 60% 70% 80% 90% 100%

Knowledge/skills to be learned

Consensus among group little some a lot complete

Agreement with tutor's list little some a lot complete

Learning objectives

Quality poor fair OK good excellent

Learning

Quality of questions asked during the teach session none some astute excellent

Willingness to continue to contribute <50% 50% 60% 70% 80% 90% 100%

Your Attitude

Perry shift 2 3 3.5 4 4.5 5

MPS 36

Learning preferences and attitudes a120

Name	Attitude: Perry scale		Learn style			Jungian			
	before	now	strategic	rote	meaning	S value and implications for learning		T value: combine with S and implications on test questions	
						value	implication	value	implication
You									

Helping your students gain the most from PBL

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Abstract:

PBL is more than an extremely effective environment to learn subject knowledge. It can be used to help students develop skill in lifetime learning, change management, teamwork, conflict resolution and problem solving. However, for this to be effective, there is much that a teacher can do to help the students acquire these abilities.

These skills need to be identified as valued outcomes of the program. Learning objectives and criteria should be created. Journal writing provides an excellent way to help students gather evidence of accomplishment. Options for assessment will be discussed.

Linda's complaint

You, a teacher in a PBL program, are talking to Linda, a student graduating from your PBL program. She confides in you, "I believe I know the expected subject knowledge but I really don't think that my problem solving skill or group skills have improved. Perhaps the curriculum planners can look more closely at the skill development being claimed in the program."

In this paper, I try to model elements of a version of PBL where

- a problem is posed, **Linda's complaint**;
- we identify issues pertinent to the problem by identifying what we know already from similar scenarios and experiences and what new information we need to know;
- we consider information and ideas about selected issues raised by the case,
- we use that information to "pose a solution" to **Linda's complaint** and then
- we elaborate that knowledge.

Consider each in turn.

1 What are the issues in this scenario?

In conventional lecture programs, the teacher will have created a set of learning objectives that he/she wishes the participants will achieve. The teacher may have used this scenario to introduce a "lecture" on the development of skill in lifetime learning, change management, teamwork, conflict resolution and problem solving.

In the context of PBL, we discuss how well the scenario or case problem is written, activating prior knowledge, ways that students can be empowered to create and prioritize the issues and some example issues.

● *Is the scenario well-crafted?*

In most PBL programs, the goal is to empower the students with the task of creating the learning objectives that are important to them. The scenario should be posed such that (Dolmans et al., 1997, Alverno College, 1977) and Drummond-Young and Mohide, 2000)

1. the learning outcomes expected by the teacher are identified correctly by the students; the scenario contains “cues” that will trigger the desired search for learning objectives;
2. the learning outcomes are consistent with the stage of development and builds on and activates prior knowledge;
3. an appropriate level of complexity is included;
4. the scenario requires integration of knowledge, skills and attitudes across topics;
5. the scenario allows an openness;
6. the scenario is motivational and relevant; the scenario is similar to one we might encounter in professional practice;
7. the scenario promotes student activity;
8. the scenario identifies the context, gives a concrete scenario and clearly identifies the expected task.

Hopefully for this conference this scenario addresses issues that are important in your application of PBL in your context. I hope it builds on and activates past knowledge. I selected this case because it resembles scenarios that I encounter frequently when I consult with different groups about PBL. This case addresses the assumption that if we use a small group, self-directed, self-assessed, problem-based learning model then this should develop skill in such “process skills” as change management, teamwork, conflict resolution and problem solving. Researchers (Norman, 1988, Norman and Schmidt, 1992, 1993, Woods, 1989, 1993a,b) report that this is a faulty assumption.

Now let’s use the case to activate prior knowledge similar to that presented in the case, **Linda’s complaint**.

● *Activating prior knowledge/experience. Have you seen something similar before?*

To facilitate learning, Schmidt (1983) emphasizes the importance of activating previous knowledge gained from “similar situations.” Have you encountered anything like this before? Perhaps you worked as a volunteer for the Red Cross in the community and the expected goals for the Red Cross program had not been achieved. An issue in Linda’s scenario is that a person in a program, Linda, feels that her expectations had not been met. Is this educational situation similar to one you have encountered previously? Maybe you felt as Linda felt. What did you do? What turned out to be the major issue?

Now that we have helped relate the case to the known, what new information is needed to resolve the problem posed in the case **Linda’s complaint**?

● *How might we empower student groups to generate the learning issues?*

The options we might use to generate the learning issues include:

- the teacher gives the student groups a list of “teacher-generated” learning objectives.
- large groups (>6 students) of students generate and prioritize a list via a tutor-facilitated discussion.
- small, tutorless groups of students generate and prioritize a list as a small group (<7 students) and their results are validated by the tutor or www program.
- small groups students with a tutor generate and prioritize a list with the tutor gently guiding the activity.

● *What are some issues that this scenario might generate?*

Some issues that might be generated by teachers with/without experience in PBL are given below. We find it useful to consider the problem from different perspectives and to focus on different cue words used in the scenario.

From the perspective of the teacher: “cues” from the case include such words as: you, teacher in PBL, confides, graduating, claim in the program.

- Does the student have the skill but doesn’t realize it? Is her skill in self assessment weak? perhaps Linda didn’t receive feedback?
- Is Linda’s expectation justified? Have we said we would develop this skill? or is she equating PBL = problem solving? small group = skill in teamwork?
- Is this a widespread concern? (Linda confides only in you; did she tell others?)

- Is this a major frustration for Linda? or is she just giving suggestions to improve the program?
- Why does she express this now instead of earlier in the program? have we poor methods of gathering student comments throughout the program? Is the issue one of monitoring the program continually?
- What actions do I, as a tutor, take to try to develop my student's skill and confidence in these skills? Should I take any?
- Do I have skills in coaching students in the development of these skills?
- Have I received training in coaching?
- What do I mean by "problem solving"? "teamwork"? what other skills and attitudes besides these are addressed in our program?
- How do I assess these skills? How do I provide feedback to the students about their skill development?

From the perspective of the student: "cues": confides, improved, I know.... but I don't think,

- What skills did Linda possess when she entered the program? should she expect to see an improvement?
- Has there been an improvement in skill but she lacks confidence?
- Has she personally benchmarked her behaviour, set personal goals, criteria and selected forms of evidence to improve? Should she be expected to do this?
- What is Linda's role and obligation? and what is the tutor's role and obligation? and what is the program's role and obligation ?
- Is this an issue of skill? or confidence in the skill? or both?
- What is Linda's definition of "problem solving"? "teamwork"? What other skills should she expect to be developed in the version of PBL she experienced?
- Linda identifies that she "knows the subject knowledge." This suggests some skill in self assessment. Can the same forms of feedback, that told her she knew the subject knowledge, be effective in telling her that she is skilled in problem solving and team work?
- If Linda feels these are important, why didn't she let us know earlier? An issue might be one of trust and openness in the learning environment or one of monitoring.

From the perspective of PBL learning process: "cues": PBL program.

- Which form of PBL was used? Is the form likely to explicitly develop the target skill?
- Class size?
- Assessment?
- Role of tutor? subject specialist? skill development specialist?
- Do all - students and staff - agree that skill development is important?

From the perspective of the program: "cues": in the program, curriculum planners

- What skills do students have entering the program? How do we know?
- What are the expected outcomes from our program? are these published? do they include confidence and skill?
- Do the tutors, teachers, students, and administration all understand the expected outcomes?
- Have we defined places, times and activities in the PBL program (or before the PBL program) for the development of the confidence and skill?
- Have we trained the tutors to be effective coaches?
- Have we trained the students?
- How do we assess the student skill?
- How do we evaluate the program effectiveness?
- How do we monitor the program?
- How do we obtain student input continually?
- Do we, as teachers, know the skill is developed but the students don't?
- How do you develop self confidence?

From the perspective of the skills: "cues": skill

- What is the definition of the skill?
- Have published learning objectives and measurable criteria been developed for this skill? How are the outcomes

- generated? How can we create measurable criteria?
- Is the skill identified as an outcome of the program?
- How is the skill assessed?
- Have we really helped the student see the skill development or have we been ineffective in communicating?

From the perspective of learning/acquiring skill: “cues”: skill, skill development

- Is developing skill established by methods similar to learning knowledge?
- How do you teach skill?
- How do you assess skill?
- How do students self assess skill?

Synthesis and prioritization of issues:

Many issues were repeated when seen from the different perspectives. However, some main issues are:

- A. issues related to developing process skills: how, when and how to assess.
- B. issues related to embedding the process skill development into and throughout the program.
- C. issues related to assessment especially as it applies to process skill and “intuitive” behaviour.
- D. issues related to developing student awareness, confidence and trust.
- E. issues related to selecting options for your approach to PBL and your culture.
- F. issues related to gathering student feedback, monitoring and program evaluation.

Lots of issues from this case! You have probably identified others.

2 Reporting back on selected issues

Here we summarize ideas for each of the six issues. Consider each in turn.

A. Developing process skills

Using small group, self-directed, self assessed, interdependent PBL assumes that the participants use (and are skilled in that use) skill in problem solving, group work, self-directedness, teaching, self assessment and communication (Woods, 1994).

How to develop: For problem solving, what doesn’t work seems to be giving the students many problems to solve, using challenging problems, watching the instructor/tutor solve the problem, watching others solve problems (Woods, 1993b). We might generalize these conclusions to the development of any skill or attitude.

What seems to be effective is to use research to identify target behaviours (see how the experts do the task); convert these into learning objectives with measurable criteria, identify forms of evidence that students can collect that show their performance, give students opportunities to try the skill, provide feedback, more practice, feedback and continue until students “believe” they have mastered the skill (Bandura, 1982, Schon, 1987, Woods et al., 1997, Woods et al., 2000a, Alverno, 1977).

Example evidence-based target skills, learning objectives, criteria, forms of evidence, and assessment are listed for problem solving, change management, group work, self assessment, conflict resolution (Alverno, 1977, Woods, 1999a,b; Woods et al. 2000a, Woods et al. 2000 b, and Woods et al. 2000c,d). Example levels of development for team skills are given in Table 1; target skills, in Table 2.

Insert Tables 1 and 2

We have used a workshop style learning environment to develop process skills (Woods et al., 1997, Woods, 1999d).

A workshop is designed to:

- help individuals become aware of how they do the skill,
- provide target skills for the effective application of the skill,
- give an opportunity to reflect and self assess,

- gives students a chance to gather evidence about individual use of the skill,
- provide benchmarks and encourage students to create goals for growth of the skill development.

Example transparencies, timing outlines and descriptions of some of the workshops are available (Woods, 1999d).

An alternative to the use of workshops is given by Alverno College. Alverno (1977) integrates the development throughout all of its courses with published lists of objectives and levels of development for each course. They have a separate assessment department to assess some skills.

When to develop: Four options that have been used include:

- prescreen and only admit students into your program who have the skills already and continue with monitoring, assessment and feedback (McMaster MD approach);
- prePBL workshops. Provide workshops before students start the PBL activities and continue with monitoring, assessment and feedback (our approach in engineering);
- integrate the workshop skill development with the early PBL cases and continue with monitoring, assessment and feedback (McMaster Theme school approach);
- integrate the development throughout the whole program with a published progression through four levels of skill development as the students move through the program (Alverno College model).

Assessment of student skill: If the objectives, criteria and forms of evidence are clearly developed and published, then assessment is easy. More on assessment is given in section C.

B. Embedding the development of process skills into PBL

To embed the skill development into the program requires action at the program or departmental level, general considerations and at the individual PBL unit level.

● Program actions:

1. Make the process skill a valued and published outcome for your program.

Example:

“Graduates of this program will think rigorously and critically and solve problems effectively and efficiently.”

2. Build student assessment and program evaluation into the program right from the start. Don't tack this on as an afterthought. How are you going to test skill in teamwork? How will an individual be graded? How do we evaluate whether our efforts are successful? How do we benchmark and set goals for growth to improve our program?

For example, all students could complete the Heppner PSI (Heppner, 1986) and the Billings-Moos inventories (Billings and Moos, 1981) at the beginning of the program to establish benchmark data. The first PBL case could address issues of teamwork, the second addresses assessment and self assessment and so on.

3. The goals, criteria and methods of assessment should be consistent across the whole program. Publish details of where and how the skill will be developed. Alverno College provides an excellent example (Alverno, 1977).

For example, “Problem solving is defined in the course pack. The focus in the first semester will be on developing...”

● General Principles

4. Treat the development of process skills with the same rigor and scholarship that you use in the development of subject knowledge.
5. Create the framework for assessment and evaluation. Details are given in Section C.
6. *Make the implicit behaviour explicit.* So much of the processing occurs automatically in our heads and in the

heads of other skilled practitioners. When asked “*How do you do that?*” she replies “*I don’t know; it just happens.*” Our task is to take the skill and behaviour apart; discover what really is important based on research, make goals and criteria and then present the experiences in bits and bites that can be mastered by our students. This provides the *context* for skill development.

7. *Encourage monitoring.* Provide a checklist of questions the students can use to monitor their process skill development. This provides the student with one form of evidence.
8. *Ask students to reflect on the process.* For each team meeting held, ask them to write out their reflections of how they did the task. This provides the student with one form of evidence.

● For your PBL activity.

9. In your syllabus, restate the program outcomes, list the outcomes that will be addressed explicitly in your course.

For example,

*In these next PBL units, you will learn new knowledge and synthesize previous knowledge to solve problems related to the cardiovascular system [the subject-specific skill development or new subject knowledge gained] **and** you will develop skill in working in teams, (or critical thinking or problem solving or communication).*

10. Know what previous training in the target process skills the students have had and build on those.
11. Use terminology, assessment forms and standards of assessment consistent with the overall program.
12. Gather benchmarking data to aid in the program evaluation.
13. Usually assign students to the groups unless there is a compelling reason to allow them to select their own groups. Keep the same groups for at least eight weeks.
14. *Assign a chairperson for every meeting.* Research has shown that groups function better with a designated chairperson. Require the chairperson to prepare and circulate an agenda ahead of time. Ask the group to give written feedback to the chairperson at the end of each meeting. The chairperson uses this input to reflect on his/her skill and to set targets for development. This provides the student with one form of evidence.
15. Work with students *at their stage of need.* For example, don’t expect team performance and use team criteria for assessment when the group is really a fairly effective group. Apply standards of assessment consistent with the level of development. Secondly, we could help them see the big picture, and nurture, encourage and reward them on their journey toward effective teamwork.

C. Principles of Assessment

Assessment we define as a judgement based on the degree to which the goals have been achieved based on measurable criteria and on pertinent evidence. We have found that breaking this definition into five principles assists in applying this definition. The five principles are: (Alverno, 1985, 1994; Woods, 1994 and Boud 1993)

1. Assessment is a judgement based on performance - not personalities. We need to help a student realize that a poor mark does not mean he/she is a bad person. The judgement is made about performance in completing a task. It has nothing to do with his/her value as an individual. This is an issue, especially for students with attitudes characterized by Perry’s level 2. More details about Perry’s levels and their implications to teaching and learning are given elsewhere (Perry, 1970; Woods, 1994; Woods et al., 2000a).
2. Assessment is a judgement based on evidence - not feelings. We might intuitively feel that a student is a good problem solver. However, we need to replace that intuitive feeling with physical evidence such as the written script

on an exam or in a project report. Help the students (and staff) gather evidence. Provide time for students to write reflections. The staff responsibility is to create well-designed standardized feedback/assessment forms. Provide practice understanding the terms and working with the forms **before** the program.

3. Assessment should be done for a purpose with clearly-defined performance conditions. The student should know when he/she is being assessed.

4. Assessment is a judgement done in the context of published goals, measurable criteria and pertinent, agreed-upon forms of evidence. Use research, not personal intuition, to identify the target skills. Publish goals with measurable criteria for process skill. Such goals should provide clear needs for documented evidence. These should be published at the start of the program so that there are no surprises for the students and no unwanted student backlash to the teacher. Examples for some process skills were described in Section A with ideas for team skills given in Tables 1 and 2. Example forms of evidence for team work are given later in this section.

5. Assessment should be based on multidimensional evidence: static and dynamic situations; small assignments and lengthy projects; academic, social and personal contexts; under a variety of performance conditions (exams and homework, written and oral, performance as an individual and as a member of a group,) formative and summative data and with different persons being the assessors (self, peer, teacher and trained external observers).

To remove ambiguity from the assessment the following six *issues in practice* should be addressed (Alverno, 1985, Woods, 1994).

1. Goals: What is being assessed? Knowledge in engineering or a discipline subject? Skills? Attitudes? Have the goals been expressed unambiguously in observable terms? Who creates the goals? Are the goals explicit and published?
2. Criteria: Are there criteria that relate to the goals? Can each criterion be measured? Who creates the criteria? Are the criteria explicit and published?
3. Form of evidence: What evidence is consistent with the criteria? Are the checklists used for the assessment asking questions related to the criteria? Do both the assessor and the student know that this form of evidence is acceptable?
4. Resources: Are the goals and the collection of the evidence possible to achieve in the time and with the resources available?
5. Assessment process: What is the purpose of the assessment? Under what conditions is the student's performance assessed? Who assesses? What type of feedback is given by the assessor? (For example, Pass fail? a grade? five strengths and two areas to work on?) What is the form of feedback? Verbal? Written? What is the timing of feedback? Who delivers the feedback?
6. Training in the assessment process: Have both the student and the assessor received training in assessment?

Failures of assessments to accomplish their purpose can usually be traced to violations of any of these five principles or to the incorrect application of the six issues in practice. The major challenges students have seem to be:

- Students can understand goals and objectives for subject knowledge. "*It's Chapter 3 in the text.*" or "*It's like the assignments we've had, only changed a little (at least we hope it is changed only a little).*" But how do you assess teamwork? An answer is that we need to create easy-to-understand and demonstratable goals.
- Students underestimate the importance of evidence. Furthermore, they have trouble seeing the types of evidence that might be useful.

Example forms of evidence for problem solving are available (Woods, Wood, Sheardown, Kourti and Crowe, 2000b). Here are some examples for team work (Woods, 2000a):

Open 1 Attendance records. No a very useful form of evidence. A person can be present and sleep through the activity (Woods, 1996).

Option 2. Test and Exams in Process Skills, TEPS: Create examinations that test the achievement of the published objectives for team skills. Some example questions are given in Resources Chapter D (Woods, 1999a).

Option 3: Peer and self assessment of individual contributions to the team using a well-designed, standardized observation/feedback form (Woods, 1994 and Woods et al., 2000d, Woods, 2000a).

Option 4: Reflective journals for individual growth. Individuals gather evidence about his/her own contributions to the team: reflections, peer feedback, agendas of meetings, documents brought to the group for a task, monitoring records.

Option 5: Reflective journals for team growth: Individuals gather evidence from the reflections about group behaviour after each group meeting, add reflections about what they personally did to help the team grow. Examples are available (Woods, 1993-95; 1999c).

Option 6: Individual assessment of team activity using a standardized form (Woods et al., 2000c).

Option 7: Observer assessment of the team performance.

Option 8: Observer assessment of the individual performance.

Option 9: Portfolio that synthesizes all the above evidence.

Option 10: Published validated questionnaires for component skills: listening, responding trust, conflict resolution. See Woods, 1999e for a listing of some possible inventories.

Option 11: Feedback or self reflection about the assessment process. Maturing and moving toward teamwork brings with it skill in self awareness, self acceptance and self assessment. The form in Table 3 can be used to provide evidence about skill in self assessment and in assessment (Woods, Marshall and Hrymak, 1988). This reminds us of the Principles of Assessment outlined above.

Insert Table 3

D. Issues related to helping students see success, developing confidence and trust.

Here are some suggestions:

- Provide frequent and prompt feedback; work in the context of evidence-based targets; require reflection and journal writing. Follow the principles of assessment. Encourage personal goal setting.
- Use validated inventories to help individuals identify his/her uniqueness and personal style (such as Kirton’s KAI, Schutz’s FIRO-B, Jungian Typology, men and women in conversation, the Perry inventory (Woods, 1994) the Lancaster Approaches to Studying (Ramsden, 1983) and Johnson’s approaches to resolving conflict (Johnson, 1986)). Help students move from self awareness to self acceptance, to acceptance of others with different styles and to self confidence.
- Alert students to the four keys to effective interpersonal relationships:

Key #1. Honour the seven fundamental rights of individuals, RIGHTS (Woods, 1994)

- R to be Respected
- I Inform or to have an opinion and express it
- G have Goals and needs.
- H have feelings and express them
- T Trouble and make mistakes and be forgiven
- S Select your response to others expectations

Claim these rights and honour these in others.

Key #2. Avoid the four Killers of relationships (Woods, 1994):

- Contempt
- Criticism
- Withdrawal and stonewalling
- Defensiveness

Key #3. Build trust. Trust glues relationships together.

We build trust by

- keeping commitments to yourself and others.
- clarifying expectations that you have of yourself and of others.
- showing personal integrity, honesty and loyalty to others, especially when they are not present.
- promptly and sincerely apologizing when you know you are wrong.
- honouring the fundamental RIGHTS listed above and avoiding the killers.
- taking time to see things from the perspectives of others.
- accepting others "warts and all."

We destroy trust by

- the reverse of the Builders of trust listed above, and
- not meeting commitments.
- selectively listening, reading and using material out of context
- not accepting experience of others as being valid.
- making changes that affect others without consultation.
- playing the broken record until you're eventually worn them out or subtly make changes in the context/issues/wording gradually so that they are unaware of what is happening until it is too late. They were sideswiped.
- asking others to give up their fundamental RIGHTS.

key #4. Give feedback to others to encourage and help them; not for you to get your kicks and put them down (Woods, 1994).

This approach applies to help build relationships between teacher/tutor and students and among students.

E. Issues related to selecting options for your approach to PBL and your culture.

PBL is an extremely effective environment for learning subject knowledge. But it also is a misunderstood, popular, flavour-of-the-month option. Some introduce PBL just because "it is the thing to do this year." In deciding what version of PBL might be appropriate for you and for your institution let's remind ourselves of basis behind PBL. Here's my version of the basics:

PBL is a learning environment where a problem is posed first **before** the students have learned the knowledge. PBL is like research: we have a conundrum to resolve; what do we have to learn/do to resolve it? There are many versions of PBL. For example, a lecturer could pose a problem first, and then lecture. *The challenge is to us this opportunity effectively to develop problem solving skill.*

PBL helps students create knowledge structures that will prompt rapid recall in future practice. The memory patterns are different from those generated when the subject knowledge is learned structured around typical textbooks. *The challenge is for us to facilitate the development of cues and the appropriate knowledge structure* (Schmidt, 1983, 1993).

Self-directed PBL empowers the students with the tasks of learning (many of which are owned by the teacher in conventional programs). Students identify learning issues, create learning objectives and criteria, contract with members of the group to learn and teach parts of the unknown stuff, teach others, elaborate and self-assess how well the learning has progressed. Students are empowered; *the challenge is that we need to make them accountable.*

Self-assessed PBL empowers the students with parts of, if not all of, the assessment. Gibbs (undated) and Novak (1989) say “whoever owns the assessment, owns the learning,” Many other options can be used to empower students with assessment (see Felder et al., 2000). PBL is one exciting option. *The challenge is to develop self-assessment skills in our students and to shift the teacher’s role so that the teacher monitors the assessment process, rather than doing the assessment.*

Small group PBL uses an active, cooperative learning environment. Research in learning (Chickering and Gamson, 1987) suggests that learning improves if students are active, work cooperatively, have clear time on task, receive prompt feedback, and are in an environment that expects success and that caters to their personal learning style. Small group PBL provides a wonderful opportunity to achieve these. *The challenge is for use to create a small group environment that does indeed include these characteristics.* Other learning environments can be designed for active learning; for cooperative learning; to provide prompt feedback (see Woods, 2000b, Felder et al., 2000), but small group PBL offers an ideal environment that applies most of the principles to improve learning.

Small group, self-directed, self-assessed PBL tends to create a learning environment that nurtures “deep” learning rather than “surface/rote” learning. The latter tends to be promoted by traditional lecture environments (Ramsden, 1983; Woods, Hrymak and Wright, 2000e).

Small group, self-directed, self-assessed PBL provides probably the best option for the development of lifelong learning skills. *The challenge is to explicitly develop lifelong learning skills following the same guidelines given Section A.*

Small group, self-directed, self-assessed, interdependent PBL may not be the format that fits your culture or your personal style. What we can do is:

- Use the knowledge of how best to facilitate student learning as the basis for choosing of learning environment.
- If small group, self-directed, self-assessed, interdependent PBL is selected, then address the challenges so that your students gain the most.

F. Issues related to gathering student feedback, monitoring and program evaluation.

Give PBL the best chance to succeed and be scholarly in your approach to program evaluation,

- Whatever approach to PBL you take, give your interventions the best chance to succeed. Whenever you try something new, most students resist.
 - *Students prefer the familiar* to something new. They know the “lecture system” and how to make it work for them to get the highest marks. If we change the familiar “system”, most resist the change (Benvenuto, 1999). When they experience change, students often follow the eight-step grieving process of shock, denial, strong emotion, resistance, acceptance, struggle, better understanding and integration (Woods et al., 2000a; Woods, 1994). To help them through the process, run a workshop.
 - *Explain why* you are making the change.
 - *Help students see their personal benefits* of the new approach in the short term and in the long term.
 - *Explain your role.* Students may believe that they are paying for teachers to “lecture.” (Benvenuto, 1999). Use Perry’s inventory (Perry, 1970, described in Woods, 1994; Woods et al., 2000a) to help students understand their perceptions; explain your role in terms of the Perry model.
 - *Monitor the program frequently.* Use ombudspersons or one minute papers (described in Felder et al., 2000) and adjust in response to their feedback.
 - *Be flexible.* If this particular class is vehemently opposed to the new approach, explore options to achieve your goals and theirs. Perhaps scale down the intervention. Gather data on how to make the intervention more effective the next time you try it.
 - *Bring in success stories.* Invite recruiters or students, from other programs where the intervention has been effective, to give testimonials at the start of your course.
 - *Help students cope with the upheaval when old habits are identified and changed.* This is particularly true

for problem solving. For example, part way through a program to develop problem solving, students complained that “*focussing on the process of problem solving has meant that they could no longer solve problems.*” We used the following analogy to help them through this frustration.

Consider that you are a reasonably good tennis player. You go to an expert to improve your game. The expert takes your game apart. As you relearn how to do each part, your game is not what it used to be. Be patient. Gradually you improve and surpass your past skills.

- *Be scholarly in your approach to program evaluation.* Unfortunately, when it comes to teaching many faculty “diddle around”. They try one thing in the classroom; then they try another. Their approach evolves like Topsy with them never sure as to what works and what doesn't. They would never do research in our subject discipline that way. In “research” they create a hypothesis, create models or experiments and test the hypothesis and draw conclusions. With just a little more effort, we can bring that same scholarship to teaching. The hypothesis is that “by making a change your students will learn more effectively and/or they will develop process skills of value to them as professionals.” Your intervention should make a change. But does it? Consider using some simple and easy-to-administer pretests and post-tests. Examples for process skills have been cited (Woods, 1999e; Woods et al., 2000b, Woods et al., 1997). Gather data from exit surveys. Queen’s University has developed an excellent survey (Queen’s, 1994). Reflect on what went on. Gather evidence. Write journal articles and seek grants. Being scholarly in your approach means that right from the start you plan how to test and monitor the effectiveness of what you do.

3. Use the new knowledge to solve a problem

In **Linda’s** context we find that:

1. Published outcomes of the program are:

“Graduates of our program will be skilled problem solvers and team players.”

2. Skill development is identified but confidence in applying the skill is inferred.
3. Few formal mechanisms are in place for gathering student feedback about the program.
4. The assessment is done by the tutor for each of the seven students in the group. The assessment is done by the tutor who ticks off boxes related to skill development.
5. Feedback to the student is through the student reading the file that includes all of her tutor’s forms. The overall grade is a Pass/fail. The student receives no guidance as to how to interpret the forms.
6. No formal training is given to the students on group skills or problem solving.
7. The tutor assumes the role of chairperson at all PBL meetings; the meeting don’t start until the tutor arrives; no agendas are circulated.
8. The feedback forms used by the tutor to assess the team skills and the problem solving skills do not include the criteria; the only time the student sees the forms is in the files.
9. The student is not asked to present evidence about her skill in problem solving or team work.
10. Some self assessment is expected but, as Linda says, “It’s a joke. We receive no training. I was surprised when you showed me the principles of assessment, in Section C. No target skills or detailed objectives and criteria are published. We just tick “Good” in all categories. If we tick “Excellent” then we know we might be challenged by the tutor. If we tick “Needs work” or “Poor” then I’m shooting myself in the foot. My rating is wishful thinking. I really wish I had some concrete evidence about my skill so I could remove the hazy feeling I have about it all. Besides, I don’t think anyone pays any attention to my rating. The only rating that counts is the tutor’s.”

Comments: This program violates most of the principles of assessment. Although the program has the development of problem solving and team skills as an outcome, there does not seem to be any formal structure to help meet that claim. Consider, in turn, the principles of assessment:

Principles 1 and 3. The assessment should be based on performance. The performance conditions were not clearly defined so that Linda did not know the conditions when she was being assessed for these skills. She assumes that the conditions are her day-to-day performance in the tutorial group. The major assessor seems to be the tutor, who plays many roles including facilitator and chair of the group. Although some self assessment is asked for, Linda is not clear about the role her self assessment plays in the overall assessment. The form she uses seems poorly designed because it lacks target skills and measurable criteria.

Principle 2. The student is not assessed based on nor is given time to produce written evidence.

Principle 4. Published goals and criteria (whether they be created by the students or created by the tutors for the program) are missing. Linda does not know any acceptable forms of evidence.

Principle 5. The many different forms of evidence that could be used are not clearly identified.

Everything seems to be based on the tutor's use of a checklist. de Stephen (1985) and Swanson et al. (1991) suggest that one assessor cannot do a reasonable assessment (via observation of a tutorial group) of more than three people at one time. In Linda's school one tutor is expected to assess seven people! in addition to facilitating the tutorial process.

A solution:

Revamp the assessment process based on the principles from Section C.

Provide training in the process skills and in self assessment for Linda and her classmates.

Adding such structure will improve student accountability.

Provide better communication between the tutors, program administrators and the students about the program and its expectations.

Provide monitoring activities, such as classroom assessment techniques, CATS (Angelo and Cross, 1993), ombudspersons or one-minute papers to provide the tutors and administrators with a better understanding of how well the teaching and learning is progressing in the context of PBL.

4 Elaborate the knowledge

Schmidt (1983, 1993) and Coles (1990, 1991) emphasize the importance of asking students to elaborate on the new knowledge. Expand on the relationship between concepts, explicitly consider how things come together, see tasks as linking together aspects of knowledge both within and between subjects. Link theory with practice, make connections. Relate the new to past knowledge. Some example tasks that help students elaborate include: private study, essay writing, problem solving in groups, preparing and presenting a paper or case, studying for exams, creating concepts maps, posing and answering questions, taking notes, discussing with others, teaching peers what they first learned themselves, summarizing, reflecting, formulating and criticizing hypotheses, writing what they DISCOVERED, extending the application to other scenarios, creating other scenarios, and extending from education to everyday life.

For **Linda's complaint**, we can extend the use of the same principles to improve staff performance reviews, to improve our interaction with our children, and to guide our goal-setting and self-improvement activities.

5. Summarizing

Instead of me presenting a summary of what I hoped to highlight in this paper, I ask you to use Table 4 and elaborate and reflect on what you discovered and rate the ideas as they apply to your situation.

 Insert Table 4

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Table 1 Example list of levels of skill development for “team skills”

● *Alverno’s model* (Alverno, 1977)

Level 1. Identify own interaction behaviors utilized in a group problem solving situation. (Eleven behaviors for the task activities used as criteria; observation by peers, strengths and weakness noted; agreement between observer and client).

Level 2. Analyze behavior of others within two theoretical frameworks: task and morale components..

Level 3. Evaluate behavior of self within two theoretical frameworks for at least three different, videotaped situations. Self, peer and teacher assessment. Growth contract created.

Level 4. Demonstrate effective social interaction behavior in a variety of situations and circumstances.

Level 5. Demonstrate effective interpersonal and intergroup behaviors in cross-cultural interactions.

Level 6. Facilitate effective interpersonal and intergroup relationships in one’s professional situation.

Forms of evidence and criteria are available.

● *MPS model* (Woods, 1999b, Woods et al., 1997; Woods, 2000a)

Level 1. Self awareness, self acceptance and acceptance of personal style and preferences of others: MPS 11

Level 2. Awareness of attributes of successful groups/teams for the two theoretical frameworks of task and morale: part I MPS 28; Groups can self assess, set goals for growth.

Level 3. Self awareness of own contributions to the group/team: MPS 28; 29. Individuals can state his/her contribution to the group process. Gather evidence about effectiveness in role as chairperson; set goals for growth. Understand the implications of FIRO-B for personal contribution to group evolution.

Level 4. Being an effective member of a “good group” MPS trust, conflict resolution, problem solving, give receive feedback, assertiveness

Level 5. Being an effective member of a team. MPS 51

Table 2 Evidence-based targets for group skills (reprinted from Woods, 2000a)

Evidence-based targets	Progress toward internalizing these targets				
	20%	40%	60%	80%	100%
● Performance improves when we have goals.					
● Assessment must be related to the goals					
● Both Task (getting the job done) and Morale (feeling good about the group work and about how you have interacted with the other group members) are important					
● Any group functions better with a chairperson.					
● Chairperson and leadership are different; different people may become leaders at different times.					
● Group evolution tends to follow a pattern described as by such descriptors as “forming, storming, norming and performing”. Schutz’s instrument FIRO-B seems to provide reliable insight as to the personal style of individuals towards other group members during three of these phases.					
● We can list the roles needed in both Task and Morale to make an effective group.					
● When each person has a clear idea of roles and group norms, the group functions better.					
● When groups are functioning effectively, about 75% of the time is spent on the task; 15% on morale building activities and 15% of task process activities (how the problem solving process is going; summarizing ideas, guiding the process).					
● The products from groups or teams is improved when members have different “styles” (in Jungian terminology some members are dominant S, and some, dominant N). The products from groups tend to be inferior when all the members “think and behave alike”.					
● The quality of decisions, product, task is improved if group members offer different perspectives, disagree and seem to introduce conflict into the process. The trick is to manage the apparent conflict well.					
● The characteristics of “meetings of individuals,” “effective groups” and “teams” fall on a spectrum with sufficient differences that it is useful to differentiate based on those characteristics					
● In a decision-making mode, after 20 minutes of discussion on any one topic, few new ideas are presented and repetition of previously stated ideas occurs.					

Table 4. Reflection about and self rating of the ideas in this paper
Reflection and DISCOVERY

Rate the ideas				
	already do this	would work	might work	not my style
Well crafted problems				
Meets learning objectives	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Contains “cues”	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
In context of the program and activates previous knowledge	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Appropriate complexity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Integrates knowledge, skill attitude across topics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Open	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Similar to one from future professional practice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Promotes student activity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Identifies context and activity, concrete	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
In your use of PBL				
Take time for students to activate previous knowledge	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Facilitate and validate the generation of learning objectives	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ask for elaboration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Developing process skills				
Create target skills based on research.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Create goals for learning and measurable criteria	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Provide opportunities for students to gather evidence	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use a workshop to develop skill	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use Alverno’s model of continual development	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Decide on When to develop: pre-screen entrants?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
develop before PBL	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
integrate development with early units	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
integrated throughout whole program	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Embedding within the program				
Publish outcomes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Build in assessment and evaluation from the start	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Identify where the skill is developed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Consistent assessment throughout	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Rate the ideas

already do this	would work	might work	not my style
--------------------	---------------	---------------	-----------------

Principles of Assessment

Based on performance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Based on evidence	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Has a purpose and performance conditions are defined	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
In the context of published goals, criteria, forms of evidence	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Multidimensional evidence	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Share experiences	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Six issues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Forms of evidence:				
Use of TEPS for process skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use reflective journal writings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use self-assessment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use peer assessment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use individual assessment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use portfolio writing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use trained observers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use assessment of the assessment process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Developing student confidence and trust

Provide prompt and frequent feedback	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Work in the context of targets	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use reflections and journal writing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use principles of assessment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Help students identify personal uniqueness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Honour seven fundamental RIGHTS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Avoid four killers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Build trust	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Give feedback that is helpful	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Select PBL style effective for you

Pose problem before students learn	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use opportunity to build problem solving skill	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Help student build knowledge structures	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Empower students with elements of the learning process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Build in student accountability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Empower students with parts of the assessment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Train and use self assessment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
See myself as monitor of the assessment process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Build in the key elements to improve learning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Try to develop “deep” learning instead of “surface”	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use PBL effectively to develop lifelong learning skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Rate the ideas

already would might not my
do this work work style

Give PBL the best chance for success

- Rationalize to students
- Use the grieving model
- See the “opportunity” in the change
- Explain your role
- Monitor via “one minute paper” or ombudspersons
- Be flexible: change if needed
- Bring in success stories: Use testimonials

Other _____

Evaluate program: be scholarly

- Write out your hypothesis
- Plan and gather data
- Use exit surveys
- Test and monitor effectiveness
- Other _____

Use new knowledge to solve the problem

- Give students with the time to solve the problem
- Other _____

Elaborate the knowledge

- Rationalize to students why elaboration is important
- Use concept maps
- Provide activities to reflect
- Extend the application to other venues
- Use DISCOVERY
- Use checklists, like this one
- Other _____

3. Large class & PBL:

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c/pbl/lc-wksp-act.

Case 2: I've got some good projects! "I want to try PBL. I have some great projects from a local company. Since my contacts in that company say that "team work" is important, I'll use groups. I have a class of about 60 students. Since I think group work is important, I'll break the class into 10 to 12 groups. To train in students in PBL I'll hand out to the students the revised PBL framework . I have modified the generic PBL framework slightly because I don't think it appropriate in a large class for them to evaluate the tutor. Here is what I'll give to the students to guide them in PBL

Stage 1: Group setting. Introduce members. Establish ground rules. Define roles of tutor and students.

Stage 2: Problem identification: Present the problem. Identify and clarify the problem. Describe the problem.

Stage 3: Idea generation: Inquire the problem, Brainstorm possible cause and effects. Generate ideas.

Stage 4: Learning issues formulation: Determine what students need to find out in order to solve the problem. Generate learning issues and action plan. Summarize and rank learning issues.

Stage 5: Self-directed learning:. Seek information.

Stage 6: Synthesis and application: Evaluate sources of information for credibility and reliability. Apply relevant researched knowledge to the problem. Conducting peer sharing of information. Analyze knowledge. Critique knowledge. Develop more learning issues if necessary. Discuss and develop solution and explanation.

Stage 7: Reflection and feedback: Self and peer feedback on group functioning, individual problem solving process, knowledge learnt, self-directed learning.

That should work! and it should be easy for me now that I have the good problems."

"Ok," says Phan, "But how will you know that they are learning anything in their groups? Or, how will you know if only one person is doing all the work? and What are you going to be doing while they are working in groups?"

"The students will have to sort out the first two questions. That's part of their training to work in groups. As for me, I'll sit at the front of the room, and probably check my e-mails since there isn't that much expected of me. My role is to give them the problem. And what neat problems I'm giving them."

Activity 1: In small group of 5 or 6, with chair _____;
reporter _____, brainstorm the issues this case raises. Identify what you know already.
Identify what you need to learn.

Prioritize the issues: criterion: what do you want to gain from this workshop in the context of the issues raised.

Task: Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. The accuracy in the group's answer matched the time available. Group avoided contributing excessive information.

None of these behaviours	Few of these behaviours but major omissions		Most features demonstrated			All of these behaviours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

None of these behaviours	Few of these behaviours but major omissions		Most features demonstrated			All of these behaviours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Individual Contribution to Task and Morale

Group Strengths

Group Areas to work on

Feedback from the Goals Meeting

Case 2:

Issues

Number identified: 1 2 3 4 5 6 7 >7

Agreement with tutor <50% 50% 60% 70% 80% 90% 100%

Knowledge/skills to be learned

Consensus among group little some a lot complete

Agreement with tutor's list little some a lot complete

Learning objectives

Quality poor fair OK good excellent

Learning

Quality of questions asked during the teach session none some astute excellent

Willingness to continue to contribute <50% 50% 60% 70% 80% 90% 100%

Your Attitude

Perry shift 2 3 3.5 4 4.5 5

Reflections:

1. What is PBL?

Problem posed first (before the students have learned anything)

Students empowered with selecting learning goals, resources, teaching each other and assessment.

Work cooperatively in small groups (with or without a tutor present in each group).

Teacher? maintain standards, “Guide on the side not sage on the stage,” monitors the process, (like a design project).

2. Options: general

PBL is an extremely effective environment for learning subject knowledge. But it also is a misunderstood, popular, flavour-of-the-month option. Some introduce PBL just because “it is the thing to do this year.” In deciding what version of PBL might be appropriate for you and for your institution let’s remind ourselves of basis behind PBL. Here’s my version of the basics:

PBL is a learning environment where a problem is posed first **before** the students have learned the knowledge. PBL is like research: we have a conundrum to resolve; what do we have to learn/do to resolve it? There are many versions of PBL. For example, a lecturer could pose a problem first, and then lecture. *The challenge is to us this opportunity effectively to develop problem solving skill.*

PBL helps students create knowledge structures that will prompt rapid recall in future practice. The memory patterns are different from those generated when the subject knowledge is learned structured around typical textbooks. *The challenge is for us to facilitate the development of cues and the appropriate knowledge structure* (Schmidt, 1983, 1993).

Self-directed PBL (SDL PBL) empowers the students with the tasks of learning (many of which are owned by the teacher in conventional programs). Students identify learning issues, create learning objectives and criteria, contract with members of the group to learn and teach parts of the unknown stuff, teach others, elaborate and self-assess how well the learning has progressed. Students are empowered; *the challenge is that we need to make them accountable.*

Self-assessed PBL (SA PBL) empowers the students with parts of, if not all of, the assessment. Gibbs (undated) and Novak (1989) say “whoever owns the assessment, owns the learning,” Many other options can be used to empower students with assessment (see Felder et al., 2000). PBL is one exciting option. *The challenge is to develop self-assessment skills in our students and to shift the teacher’s role so that the teacher monitors the assessment process, rather than doing the assessment.*

Small group PBL (SG PBL) uses an active, cooperative learning environment. Research in learning (Chickering and Gamson, 1987) suggests that learning improves if students are active, work cooperatively, have clear time on task, receive prompt feedback, and are in an environment that expects success and that caters to their personal learning style. Small group PBL provides a wonderful opportunity to achieve these. *The challenge is for use to create a small group environment that does indeed include these characteristics.* Other learning environments can be designed for active learning; for cooperative learning; to provide prompt feedback (see Woods, 2000b, Felder et al., 2000), but small group PBL offers an ideal environment that applies most of the principles to improve learning.

SG, SDL, SA PBL tends to create a learning environment that nurtures “deep” learning rather than “surface/rote” learning. The latter tends to be promoted by traditional lecture environments (Ramsden, 1983; Woods, Hrymak and Wright, 2000e).

SG, SDL, SA PBL provides probably the best option for the development of lifelong learning skills. *The challenge is to explicitly develop lifelong learning skills by making learning objectives, helping students gather evidence and requiring assessment journals.*

Small group, self-directed, self-assessed, interdependent PBL may not be the format that fits your culture or your personal style. What we can do is:

- Use the knowledge of how best to facilitate student learning as the basis for choosing of learning environment.
- If small group, self-directed, self-assessed, interdependent PBL is selected, then address the challenges so that your students gain the most.

2. Options especially appropriate for large classes 5-500.

For details and examples of these see Chapter A in Woods, “Resources to gain the most from PBL” downloadable from

<http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL

	already use	might work	not for me
3. Osterman feedback lecture: Pose problem first, lecture in 20 min bursts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. Branda’s PBEE: Individual SDL PBL	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. Socratic: SG, SDL, PBL	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. Guided Design: SG, instruction directed PBL	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. Tutorless groups: SG,SDL,SA PBL	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. Challenges in working with Tutorless groups

Challenges to making this work:

structure, structure, structure... without interfering with the process.

Specific challenges related to students working in tutorless groups:

- apparent conflict because all members are not seen as pulling their fair share of the work
- attendance
- trust and reliability
- different work goals and standards among different students that leads to conflict.
- the amount of reflection, monitoring and writing they must do in self assessment and accountability.

Our approach has been to focus on making the students accountable (topic 8) and developing their skill and confidence in the process skills (topic 9).

8. Making students Accountable

Accountable for the learning, the teaching, the problem solving, the goals and goal setting, the critical reasoning, the location of literature and information, validation of the information, the team work, the conflict resolution, the communication, change management, lifelong learning skill development, the assessment, the self assessment, the ownership of the process and skill as chairperson. Accountable to peers, to self and to tutor, but primarily to self and peers.

- Base the activities and skill development on research - not intuition. See target skills: download from the specific MPS unit

<http://www.chemeng.mcmaster.ca/innov1.htm> and click on MPS (McMaster Problem Solving program)

- Use a framework of assessment for the accountability. Five principles and Six issues in practice.

Five Principles:

Principle 1. Assessment is a judgement based on performance - not personalities. We need to help a student realize that a poor mark does not mean he/she is a bad person. The judgement is made about performance in completing a task. It has nothing to do with his/her value as an individual. This is an issue, especially for students with attitudes

characterized by Perry's level 2.

Principle 2. Assessment is a judgement based on evidence - not feelings. We might intuitively feel that a student is a good problem solver. However, we need to replace that intuitive feeling with physical evidence such as the written script on an exam or in a project report. Help the students (and staff) gather evidence. Provide time for students to write reflections. The staff responsibility is to create well-designed standardized feedback/assessment forms. Provide practice understanding the terms and working with the forms **before** the program.

Principle 3. Assessment should be done for a purpose with clearly-defined performance conditions. The student should know when he/she is being assessed.

Principle 4. Assessment is a judgement done in the context of published goals, measurable criteria and pertinent, agreed-upon forms of evidence. Use research, not personal intuition, to identify the target skills. Publish goals with measurable criteria for process skill. Such goals should provide clear needs for documented evidence. These should be published at the start of the program so that there are no surprises for the students and no unwanted student backlash to the teacher.

Principle 5. Assessment should be based on multidimensional evidence: static and dynamic situations; small assignments and lengthy projects; academic, social and personal contexts; under a variety of performance conditions (exams and homework, written and oral, performance as an individual and as a member of a group,) formative and summative data and with different persons being the assessors (self, peer, teacher and trained external observers).

To remove ambiguity from the assessment the following six *issues in practice* should be addressed (Alverno, 1985, Woods, 1994).

1. Goals: What is being assessed? Knowledge in engineering or a discipline subject? Skills? Attitudes? Have the goals been expressed unambiguously in observable terms? Who creates the goals? Are the goals explicit and published?
2. Criteria: Are there criteria that relate to the goals? Can each criterion be measured? Who creates the criteria? Are the criteria explicit and published?
3. Form of evidence: What evidence is consistent with the criteria? Are the checklists used for the assessment asking questions related to the criteria? Do both the assessor and the student know that this form of evidence is acceptable?
4. Resources: Are the goals and the collection of the evidence possible to achieve in the time and with the resources available?
5. Assessment process: What is the purpose of the assessment? Under what conditions is the student's performance assessed? Who assesses? What type of feedback is given by the assessor? (For example, Pass fail? a grade? five strengths and two areas to work on?) What is the form of feedback? Verbal? Written? What is the timing of feedback? Who delivers the feedback?
6. Training in the assessment process: Have both the student and the assessor received training in assessment?

● Create learning goals for all activities, skills and attitudes being developed. Download examples from Chapter D in Woods, "Resources to gain the most from PBL" downloadable from <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL

● Develop forms of evidence. The forms will make performance (or lack thereof) visible. Form are evidence to be used for assessment. Use assessment journals are the key evidence for assessment.

Example forms of evidence are given as Appendices.

● Especially with tutorless groups, use forms of evidence that make individual performance visible (and accountable).

9. Developing the process skills

What to develop: skills needed for the learning, the teaching, the problem solving, the goals and goal setting, the

critical reasoning, the location of literature and information, validation of the information, the team work, the conflict resolution, the communication, change management, lifelong learning skill development, the assessment, the self assessment, the ownership of the process and skill as chairperson. The basics include: problem solving, team work, self assessment, teaching, and lifelong learning.

How to develop: For problem solving, what doesn't work seems to be giving the students many problems to solve, using challenging problems, watching the instructor/tutor solve the problem, watching others solve problems (Woods, 1993b). We might generalize these conclusions to the development of any skill or attitude.

What seems to be effective is to use research to identify target behaviours (see how the experts do the task); convert these into learning objectives with measurable criteria, identify forms of evidence that students can collect that show their performance, give students opportunities to try the skill, provide feedback, more practice, feedback and continue until students "believe" they have mastered the skill (Bandura, 1982, Schon, 1987, Woods et al., 1997, Woods et al., 2000a, Alverno, 1977).

Example evidence-based target skills, learning objectives, criteria, forms of evidence, and assessment are listed for problem solving, change management, group work, self assessment, conflict resolution

We have used a workshop style learning environment to develop process skills. A workshop is designed to:

- help individuals become aware of how they do the skill,
- provide target skills for the effective application of the skill,
- give an opportunity to reflect and self assess,
- gives students a chance to gather evidence about individual use of the skill,
- provide benchmarks and encourage students to create goals for growth of the skill development.

Example transparencies, timing outlines and descriptions of some of the workshops are available (Woods, 1999d).

When to develop: Four options that have been used include:

- prescreen and only admit students into your program who have the skills already and continue with monitoring, assessment and feedback (McMaster MD approach);
- prePBL workshops. Provide workshops before students start the PBL activities and continue with monitoring, assessment and feedback (our approach in engineering);
- integrate the workshop skill development with the early PBL cases and continue with monitoring, assessment and feedback (McMaster Theme school approach);
- integrate the development throughout the whole program with a published progression through four levels of skill development as the students move through the program (Alverno College model).

How to Embed the development of process skills into PBL

To embed the skill development into the program requires action at the program or departmental level, general considerations and at the individual PBL unit level.

● Program actions:

1. Make the process skill a valued and published outcome for your program.

Example:

"Graduates of this program will think rigorously and critically and solve problems effectively and efficiently."

2. Build student assessment and program evaluation into the program right from the start. Don't tack this on as an afterthought. How are you going to test skill in teamwork? How will an individual be graded? How do we evaluate whether our efforts are successful? How do we benchmark and set goals for growth to improve our program?

For example, all students could complete the Heppner PSI (Heppner, 1986) and the Billings-Moos inventories (Billings and Moos, 1981) at the beginning of the program to establish benchmark data. The

first PBL case could address issues of teamwork, the second addresses assessment and self assessment and so on.

3. The goals, criteria and methods of assessment should be consistent across the whole program. Publish details of where and how the skill will be developed. Alverno College provides an excellent example (Alverno, 1977).

For example, "Problem solving is defined in the course pack. The focus in the first semester will be on developing..."

● General Principles

4. Treat the development of process skills with the same rigor and scholarship that you use in the development of subject knowledge.

5. Create the framework for assessment and evaluation.

6. *Make the implicit behaviour explicit.* So much of the processing occurs automatically in our heads and in the heads of other skilled practitioners. When asked "How do you do that?" she replies "I don't know; it just happens." Our task is to take the skill and behaviour apart; discover what really is important based on research, make goals and criteria and then present the experiences in bits and bites that can be mastered by our students. This provides the *context* for skill development.

7. *Encourage monitoring.* Provide a checklist of questions the students can use to monitor their process skill development. This provides the student with one form of evidence.

8. *Ask students to reflect on the process.* For each team meeting held, ask them to write out their reflections of how they did the task. This provides the student with one form of evidence.

● For your PBL activity.

9. In your syllabus, restate the program outcomes, list the outcomes that will be addressed explicitly in your course.

For example,

In these next PBL units, you will learn new knowledge and synthesize previous knowledge to solve problems related to the cardiovascular system [the subject-specific skill development or new subject knowledge gained] and you will develop skill in working in teams, (or critical thinking or problem solving or communication).

10. Know what previous training in the target process skills the students have had and build on those.

11. Use terminology, assessment forms and standards of assessment consistent with the overall program.

12. Gather benchmarking data to aid in the program evaluation.

13. Usually assign students to the groups unless there is a compelling reason to allow them to select their own groups. Keep the same groups for at least eight weeks.

14. *Assign a chairperson for every meeting.* Research has shown that groups function better with a designated chairperson. Require the chairperson to prepare and circulate an agenda ahead of time. Ask the group to give written feedback to the chairperson at the end of each meeting. The chairperson uses this input to reflect on his/her skill and to set targets for development. This provides the student with one form of evidence.

15. Work with students *at their stage of need.* For example, don't expect team performance and use team criteria for assessment when the group is really a fairly effective group. Apply standards of assessment consistent with the level of development. Secondly, we could help them see the big picture, and nurture, encourage and reward them on their journey toward effective teamwork.

Example workshops

<http://www.chemeng.mcmaster.ca/innov1.htm> and click on MPS for the specific materials

Also see Woods "PBL: Resources to gain the most from PBL." Chapter B for

- What is PBL?
- Managing Change MPS 49
- Problem solving MPS 4
- Interpersonal skills MPS 52
- Group skills MPS 28
- SDL MPS 36
- Self assessment MPS 3
- Goal setting, issue clarification MPS 30
- Coping creatively with conflict MPS 45

A listing and brief description are given in downloadable form from Chapter 3 in Woods “Helping your students gain the most from PBL” <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL.

Reflections:

Enrichment:

1. Please help me understand how best to help you
2. MRIQ
3. MPS 4, MPS 28 (goals, targets, workshop, timing) FIRO-B; Norm meeting

References:

<http://www.chemeng.mcmaster.ca/Innov1.htm> and download MPS materials
Woods “Problem-based Learning: resources to gain the most from PBL” Chapter D for objectives. downloadable from <http://www.chemeng.mcmaster.ca/innov1.htm> and PBL; and Chapters B and C.
Woods “Problem-based Learning: helping your students gain the most from PBL” Chapter 3 downloadable from <http://www.chemeng.mcmaster.ca/innov1.htm> and PBL for an overview of the process skills.
Woods, D.R. et al., “Tutored versus tutorless groups in PBL,” Am. J. Pharm. Ed., 60, 231-238, 1996

Feedback forms

Some of the major feedback forms are given here for convenience:

- General awareness and skill for the process skills
- Assessment skills Form **301**
- Problem solving Form **401**
- Self-monitoring of stress management skills Form **501**
- Group skills Forms **2800 ff**
- Self-directed learning skill Forms **3600 ff**

Form 000 Monitoring progress with processing skills (rate your awareness & skill at the end of each session, or week, on a scale from 0 [very low] to 10 [highest])

Processing skill	rating of Awareness				rating of Skill			
	1	2	3	4	1	2	3	4
Change management and stress: anticipate and describe stages, identify stages of anger and withdrawal and move through these, identify cause of confusion, explore corrective actions, implement and reflect and manage impatience; manage stress by worrying only about elements under your control, use positive self-talk, keep situation in perspective and has positive activities to relax and maintain health and sparkle.								
Problem solving: aware of process, uses a variety of methods, emphasis on accuracy, active, monitors and reflects, organized and systematic, flexible and sees situation from many different perspectives, objective and critically assess information, welcomes challenge, spend time defining problems, uses fundamentals, and uses explicit criteria for decision-making								
Interpersonal and group skills: as a group addresses <u>Task</u> : problem defined, explored, alternatives considered, criteria identified, task completed and look back and checked. Monitoring occurred. Task completed on time. Group avoids contributing excessive and irrelevant information; sticks to main themes without meaningless side tasks; and <u>Morale</u> : group is relaxed, enjoyed working together, gave emotional support to each other and were able to express disagreement or disappointment directly. members enthusiastic and involved.								
Team skills: maintenance of group attributes plus evolution of a group to develop team goals and willingly foregoes personal goals for the benefit of the team, each knows, accepts and performs role, decisions by consensus, conflicts are resolved so that $2+2 = 7$								
Chairperson skills: prepares and distributes detailed agenda, does the necessary detail work ahead of time so as to have a "team event", facilitates the meeting [knowing when to be neutral and when proactive facilitation skills are needed]								

Monitoring progress with processing skills (rate your awareness & skill at the end of each session, or week, on a scale from 0 [very low] to 10 [highest])

Feedback about problem solving Form 401

Feedback about assessment Form 301

Goals: Content is well identified, goals are challenging and achievable, goals are written in observable terms, goals are unambiguous, the "given" conditions are specified.

None of these behaviours	Few of these behaviours but major omissions		Most features demonstrated		All of these behaviours	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Criteria: Criteria are consistent with the goals and are measurable and practical. The criteria are challenging and achievable.

None of these behaviours	Few of these behaviours but major omissions		Most features demonstrated		All of these behaviours	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Evidence: The type and quality of evidence gathered is consistent with the goals and criteria. The evidence has been gathered conscientiously over a long enough period of time. The evidence is well organized. The quality and extent of evidence is sufficient to allow me to judge the extent to which the goals have been achieved.

None of these behaviours	Few of these behaviours but major omissions		Most features demonstrated		All of these behaviours	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Process: The assessment process has been applied and as an independent assessor I concur with the decision as to the degree to which the goals have been achieved.

None of these behaviours	Few of these behaviours but major omissions		Most features demonstrated		All of these behaviours	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Strengths

Areas to work on

-----	-----
-----	-----

from D.R. Woods, "How to Gain the Most from Problem-based Learning" (1994)

Attribute		Assessment
Awareness	+ can describe processes, can distinguish "exercise solving" from "PS."	
	- unaware of process; it's intuitive; cannot define a framework for PS.	
Variety of PS skills	+ can apply a variety of methods and hints.	
	- knows very few techniques; attempts to use a "one-step" solution.	
Emphasis on accuracy	+ checks, double checks, rechecks; concern for accuracy.	
	- concern for speed; unwilling to check.	
Active	+ writes things down, makes lists, prioritizes, makes tables and sketches;	
	- thinks in head, can't keep track, stares at paper.	
Monitors & reflects	+ assesses continually, assesses potential of ideas & options; continually evaluates and curtails; asks "where is this getting me?"	
	- does not monitor or assess; just does something.	
Organized & systematic	+ plans, anticipates, develops and uses a systematic plan.	
	- trial & error, impulsive, jumps around; no plan.	
Flexible & sees OPV	+ keeps options open; sees different points-of-view, willing to discard.	
	- quickly becomes fixed on one or two ideas or options even when mounting evidence proves these to be untenable; unwilling to discard.	
Use of knowledge: objective & critically assesses	+ objective, learns from others, critically assesses data.	
	- fails to draw on past experience, egocentric, assumes & believes everything they are told; accepts all information without question.	
Welcomes challenge	+ identifies disequilibrium as good; welcomes change and confusion.	
	- considers confusion to be "bad."	
Time allocation	+ spends most of time in exploring, defining, planning and engage stages.	
	- spends most time doing, calculating, writing.	
Overall approach	+ based on fundamentals, underlying principles, needs & goals.	
	- searches for sample solutions & cooks to try to make them work.	
Decision-making	+ applies criteria, draws conclusions substantiated by evidence.	
	- makes a selection based on "gut" reaction.	

Strengths

Areas to work on

----- from D.R. Woods "How to Gain the Most from PBL," 1994.

Monitoring checklist for stress management Form 501

Ideas	Not for me	Might work	OK	Use now
1. Worry only about things over which you have control				
2. Take care of yourself: exercise, eat and sleep regularly				
3. Use <u>destimulating</u> activities: deep breathing, muscle relaxation				
4. Use positive, not negative, self-talk: Rate your self-talk: don't know very negative neutral very positive				
5. Plan ahead				
6. Rename the stressful event: don't know use anxious name neutral "thing" positive				
7. Have a support system of family and friends. don't know have none few some many Have support system of traditions don't know have none few some many				
8. Use positive addictions that take your mind away to another world: music, hot bath, crafts, hobbies				
9. Be decisive				
10. Put it into perspective: "It's not the end of the world!"				
11. Use role models who have succeeded. don't know have none few some many				
Current stress: Symptoms	none	few	some	many
As measured by Holmes-Rahe (1967) or Holmes Gmelch (1983)	<100	101-300	301-500	>501

Evidence-based targets for group skills (reprinted from references 4,17) Form **2800** .

Evidence-based targets	Progress toward internalizing these targets				
	20%	40%	60%	80%	100%
● Performance improves when we have goals. ^[18]					
● Assessment must be related to the goals ^[19]					
● Both Task (getting the job done) and Morale (feeling good about the group work and about how you have interacted with the other group members) are important ^[19]					
● Any group functions better with a chairperson ^[20]					
● Chairperson and leadership are different; different people may become leaders at different times. ^[20]					
● Group evolution tends to follow a pattern described as by such descriptors as “ forming, storming, norming and performing” ^[19,20] . Schutz’s instrument FIRO-B ^[12,21] seems to provide reliable insight as to the personal style of individuals towards other group members during three of these phases.					
● We can list the roles needed in both Task and Morale to make an effective group. ^[19]					
● When each person has a clear idea of roles and group norms, the group functions better. ^[19]					
● When groups are functioning effectively, about 70% of the time is spent on the task; 15% on morale building activities and 15% of task process activities (how the problem solving process is going; summarizing ideas, guiding the process). ^[22]					
● The products from groups or teams is improved when members have different “styles” (in Jungian terminology some members are dominant S, and some, dominant N). The products from groups tend to be inferior when all the members “think and behave alike”. ^[23,24, 19,20]					
● The quality of decisions, product, task is improved if group members offer different perspectives, disagree and seem to introduce conflict into the process. The trick is to manage the apparent conflict well. ^[19,23,24]					
● The characteristics of “ meetings of individuals,” “effective groups” and “teams” fall on a spectrum with sufficient differences that it is useful to differentiate based on those characteristics					
● In a decision-making mode, after 20 minutes of discussion on any one topic, few new ideas are presented and repetition of previously stated ideas occurs. ^[25]					

Feedback about the group work. Form **2802**

Form 2804, Self and peer assessment of contributions to team work (developed by C.M. Crowe and used with his permission)

Name

<p>Assessment of the group</p> <p>(10) Group worked well together, making the project more interesting. (5) Group usually worked well together, with occasional difficulties (0) Group could not work together at all, making the project more difficult</p>	
---	--

Please enter a mark from 0 (worst) to 10 (best) in each row, for yourself and the other members of your team or group. If you cannot make an assessment, enter U for Unable to Observe. Your assessment should be about performance and should be based on evidence you have seen or heard.

<i>Enter your initials in the first cell to the right and those of the other members of your group in the remaining cells</i>	self					
<p>Leadership</p> <p>(10) Provided direction, inspired the others (5) Willing follower, took direction easily (0) Frustrated the group, blocked progress, criticized the others</p>						
<p>Cooperation</p> <p>(10) Worked readily with the others, contributed to the group work (5) Cooperated with occasional prompting (0) Rarely contributed, worked mostly alone, had to be coerced into cooperating or would not cooperate.</p>						
<p>Initiative</p> <p>(10) Produced good ideas which helped others, solved problems (5) Accepted other's ideas and improved on them (0) Criticized other's ideas, never contributed his/her own ideas'</p>						
<p>Attitude</p> <p>(10) Positive, encouraging the others to work better (5) Neutral, worked well with the group without enthusiasm or grumbling (0) Negative, complained about the project, worked unwillingly with the group</p>						
<p>Computation</p> <p>(10) Helped others to understand and use computer tools better (5) Good but not innovative in using the computer tools (0) Uninterested or unable to use computer tools effectively; needed constant help to become useful at computing</p>						
<p>Effort</p> <p>(10) Worked very hard on tasks assigned by the group or on his/her own (5) Worked reasonably hard, given other courses and commitments (0) Did not work much at all, tasks were either not done or were unsatisfactory</p>						

<p><i>Enter your initials in the first cell to the right and those of the other members of your group in the remaining cells</i></p>	self					
<p>Research</p> <p>(10) Found many additional published papers, contacts or internet sites which greatly helped the project (5) Read only the assigned material and used that knowledge effectively (0) Had not read any material about the project, relied on others for information</p>						
<p>Communication and written reports</p> <p>(10) Organized and wrote major parts of the report (5) Contributed his/her share of the writing of the report (0) Made little or no contribution to writing of reports.</p>						
<p>Individual assignments</p> <p>(10) Did all of them on his/her own, helped others (5) Did most of them, perhaps with some help from others (0) Either did few of them or most of them handed in were copied.</p>						
<p>Pertinent technical/subject Knowledge</p> <p>(10) Excellent grasp of the technical fundamentals for this project and shared and used this effectively (5) Reasonable understanding of the basics and used this effectively (0) Little or superficial understanding, relied on others</p>						

Some evidence-based targets for Lifelong learning skills, Form 3600 © copyright, Donald R. Woods, 1999 (10-16)

Lifetime learning we define as learning how to learn so that whatever comes our way we empower ourselves to master the new knowledge.					
Evidence-based targets	Progress toward internalizing these targets				
	20%	40%	60%	80%	100%
● Consider peers and classmates as resources to help me see my learning needs, to help me plan my learning and to provide new ideas so that I can learn from them.					
● Able to assess learning needs realistically.					
● Able to create observable, unambiguous and achievable learning objectives to match or satisfy my needs. Use these to assess progress.					
● Can relate to teachers and instructors as resources, facilitators and helpers rather than as the sole source of knowledge. Have acquired an attitude toward learning comparable to Perry level 5.					
● Able to identify people and material resources needed to achieve my learning objectives.					
● Able to shift from being a dependent learner through being an independent learner to being an interdependent learner.					
● Able to devise a time plan and stick to it reasonably well.					
● Willing to assume responsibility and ownership for the tasks in learning: (goal setting, resource identification, learning, assessment).					
● Meets contract commitments to teach others.					
● When teaching others, uses the principles of learning and addresses differences in learning styles (instead of “reporting information” and expecting the learner to sort it out).					
● When learning a “difficult” topic, willing to accept the challenge to unravel the complexity (instead of skipping over it and “hoping it won’t be on the exam”).					

Feedback for interdependent, self-directed learning Form 3601

Feedback to _____ for Unit ____ Date _____
 Present & on time: Present but late by ____ min. Absent

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these.	A few but major omissions.		Most of these.		All of these.	
O _____	O _____	O _____	O _____	O _____	O _____	O _____
1	2	3	4	5	6	7

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these.	A few but major omissions.		Most of these.		All of these.	
O _____	O _____	O _____	O _____	O _____	O _____	O _____

Followup: from this presentation I will have to:

Must study subject on my own; I learned nothing from your presentation.	Major self-study needed. I have some starting references from your presentation.	Some self-study of the basics.	No self-study of the basics. I want to reflect about the ideas.
O _____	O _____	O _____	O _____

Strengths

Areas to Improve on

from D.R. Woods, "How to Gain the Most from PBL," (1994)

Feedback for PBL/SDL a120 3602

Situation\$1

Issues

Number identified: 1 2 3 4 5 6 7 >7

Agreement with tutor <50% 50% 60% 70% 80% 90% 100%

Knowledge/skills to be learned

Consensus among group little some a lot complete

Agreement with tutor's list little some a lot complete

Learning objectives

Quality poor fair OK good excellent

Learning

Quality of questions asked during the teach session none some astute excellent

Willingness to continue to contribute <50% 50% 60% 70% 80% 90% 100%

Your Attitude

Perry shift 2 3 3.5 4 4.5 5

Name	Attitude: Perry scale		Learn style			Jungian			
	before	now	strategic	rote	meaning	S value and implications for learning		T value: combine with S and implications on test questions	
						value	implication	value	implication
You									

Table 29-1: Date of meeting: _____ Group: _____ Chairperson: _____

Agenda circulated ahead of time, yes no ; start on time, yes no ; end on time, yes no

● **Task:** Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. The accuracy in the group's answer matched the time available. Group avoided contributing excessive information.

None 1 Few but major omissions 2 Most features demonstrated 4 All of these behaviours 6

Total	Agenda: Names, time, place, purpose, prework, bring, topics, timing	Use of agenda: Keep on topic, effectively & not disruptively keep on time, 20 min rule	Facilitation as needed when team functioning below norms on Task
15 to 20	Excellent & ahead of time	Used very well	Mega positive: clarified, brought back on task, monitored Task
10 to 14	Poor & ahead of time	OK	Some positive as needed: clarified, back on task, monitored Task
5 to 9	Excellent but handed out at start	Fair	Neutral because working well
0 to 4	Poor and handed out at start		
0 to -4	Excellent created at start	Poorly	Neutral when help was needed or unskilled and unable to help
-5 to -9	Poor created at start		
-10 to -15	No agenda	Not used	Kept dominating as leader, when facilitator need, Solved problem for group, when they didn't want that solution
-16 to -20			Mega negative, imposed own ideas and answers. Dictator

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

None 1 Few but major omissions 2 Most features demonstrated 4 All of these behaviours 6

Total	Agenda:	Use of agenda:	Facilitation as needed when team functioning below norms on Morale
15 to 20	Excellent & ahead of time	Used very well. Comfort high because know goals	Skilled observer of interpersonal process, praiser, facilitates, conflict resolution and provides tension relief as needed.
10 to 14	circulated ahead but missing prework & bring	Comfort moderate, can infer what to do ahead of time	Some skill and intervention
0 to 9		Fair	No intervention because all working well
-1 to -9	Some frustration; feel ill-prepared because didn't know what to prework or bring	Poor	No intervention when help was needed or unskilled in facilitation
-10 to -15	No agenda, High distress	Not used, high distress because unclear as to where going	Some, causes lower-than-norm morale because of criticism, defensiveness, contemptuousness, stubborn, conflict
-16 to -20			Mega causes tension, seeks personal goals, critical, abusive, self centered and defensive, contemptuous, ignores others

Personal Satisfaction with decisions made: 0 extremely dissatisfied...5 OK..... 10 very satisfied

● **Strengths**

Areas to work on

4. PBL: Decisions for Planning and Action: Why? When? Who? Where? What? How?

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McMaster University
Hamilton Canada

c/pbl/plan

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Here is an approach to decision-making. This is biased. This is based on my experience and may not work for you.

Step 1. Profile of your graduates from your program:

distribute 100 points among:

subject knowledge:	_____
skills:	
problem solving	_____
team work	_____
self assessment	_____
manage change	_____
lifelong learning	_____
other:	_____
attitudes:	
ethics	_____
environment	_____
impact on society	_____
other	_____

If 100 points to subject knowledge, then go to Step 4

If some points given to skills, then go to Step 2.

Step 2. Skills are important to develop for your graduates.

Then: we should

2a. Publish a calendar or university catalog description of outcomes. Example Figure 2-1.

2b. Use standard consistent forms and criteria for assessing student performance throughout the whole program (so that we don't use Form A in course 202; then form B in course 302; form D in course 444.) Example Communication skills Form Figure 2-2.

2c. Ensure that assessment is consistent with development and goals. For example, 80% on subject knowledge and 20% on teamwork. Example syllabus. Download from Chapter D, "PBL *Resources* to gain the most from PBL" which is downloadable from <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL

2d. Select methods for program evaluation and benchmarking progress.

Please identify specific skill and go to Step 3.

Step 3. Specific skill development.

Common to the development of most skills are the following features:

3.1. We create observable, published goals and measurable criteria describing the skill explicitly. Examples see Chapter D, "PBL *Resources* to gain the most from PBL" which is downloadable from <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL

Figure 2-1 Example University catalog description

“Graduates of this program in Chemical Engineering will:
- be technically sophisticated with an emphasis on the fundamentals.
- be not only computer literate but also able to program effectively and efficiently and would be familiar with a wide range of process flow-sheeting programs, such as HYSIS.
- have enriched experiences through senior electives drawn from our Department’s research expertise.
- have skills in lifelong learning, communication, problem solving, interpersonal and group work and
- know how to create hypotheses, perform experiments and draw valid conclusions.
- have a professional attitude with
- concern for safety and the environment
- ethical standards.”

Figure 2-2 Example feedback form for the product of written or oral communications© Donald R. Woods 2000

Criterion	Oral	Written	Assessment
Audience: answers questions & needs of the audience	positive answers my questions, speaks at my level, seems interested in me	understandable, writes at a level I can understand, define words; main theme is question I want answered.	
	negative talks above me, uses jargon, information dump with no attempt to answer my questions; tells me what he/she knows; gives chronological history	writes above me, uses jargon, inconsistent, complex ideas are not explained;	
Content: provides factual evidence to substantiate claims	positive supports statements with evidence	gives supporting evidence and elaboration; counter arguments given; references given	
	negative no supporting evidence, want me to believe because “I say so.”	no references, makes arguments without logic; uses humor and narrative	
Organization: well organized	positive: advance organizers, gains interest, provides summary; gives transitions from one section to the next	good coordination and subordination; no single sub-points. Advance organizers, summary, transitions between sections	
	negative rambles; jumps from topic to topic, no summary, no pattern	outline suffers from faulty coordination and faulty subordination;	
Style: interesting	positive: interesting, variety of visual and voice, good eye contact, gestures, quality Power point or visuals, clarity, quality and good diction	coherent, interesting writing style. Variety in sentence length. Deletion of extraneous and ambiguous phrases/words.	
	negative no eye contact, crazy gestures, incoherent sentences, Uummm, Ahhhs	vague and boring words, long involved sentences	
Format/mechanics: follows expected standards	positive. Begin and end on time; correct use of language; credible, visuals legible	correct format and referencing, grammar, spelling & punctuation are correct Neat.	
	negative runs over time; visuals upside down; grammatical mistakes	did not follow conventions in discipline	

3.2. We agree on forms of evidence that students can use to document achievement. See papers by Woods in the journal *Chemical Engineering Education* called “Assessing...” published in 2001. Woods, Taylor, Jaffer “Teams” (2001c and d); Woods et al., “Problem Solving,” (2000b); Woods “Lifelong learning,” (2000a); Woods (2000a).

3.3. We expect students to write assessment journals for the progressive development of the skill. For example see Chapter F, “PBL *Resources* to gain the most from PBL”

3.4. We select an appropriate learning environment to develop the skill and student confidence in the use of the skill. Table 3-1 lists recommended learning environments to develop different skills.

Table 3-1. Suggested learning environments to develop skills

Skill	Learning environment	comment and resources
communication, written	personal projects with emphasis on both the process and the product	we have found that the key is to select topics of interest to the students plus personal guidance. See Postface, page P-6 in “Helping your students gain the most from PBL” <i>Helping</i>
communication, oral	videotape plus personal feedback	
communication, interpersonal	workshops	In the MPS program, MPS 52 and 26, 27
problem solving	workshops	In the MPS program, about 75 h of workshops with a minimum of 4 h, MPS 4. Chapter 3 in <i>How to Gain the Most from PBL, HTGTM</i>
team work	workshops	In the MPS program, about 45 h of workshops with a minimum of 6 h: conflict resolution, MPS 45; group process, MPS 28. Chapter 5 in <i>How to Gain the Most from PBL, HTGTM</i>
change management	workshops	In the MPS program, unit MPS 49; Chapter 1 in <i>How to Gain the Most from PBL, HTGTM</i>
self assessment	workshops; personal goal project	In the MPS program, MPS 3 and in Woods, Marshall and Hrymak (1988) and Chapter 9 in <i>How to Gain the Most from PBL, HTGTM</i>
lifelong learning	small group, self assessed, self-directed PBL see Step 7.	In addition in the MPS program MPS 36 and in <i>How to Gain the Most from PBL, HTGTM</i>

With **small group, self directed, self assessed PBL** students have an *opportunity* to practice problem solving, self assessment, group skills and communication skills. Our experience has been that the use of PBL does not initially develop or build the skills.

3.5. Calendar or university catalog descriptions should include the development of the skills as explicitly planned activities. Example, “Course YYY, The... subject content. Team skills and self assessment skills. 3 lectures per week, one 2 -h tutorial. Prerequisite.... Corequisite...”

3.6. We need to identify where in the overall curriculum the skills are a) initially developed. b) used. Planner A in Table 3-2. Example from Spencer-Chapman (1996) for a traditional course/subject curriculum.

Table 3-2 Planner

Outcomes	Subjects, courses or PBL cases														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Subject knowledge															
Skills:															
communication															
problem solving															
team work															
change management															
self assessment															
lifelong learning															
Attitudes:															
ethics															

At this time we have completed our look at the development of process skills. We will consider some details of how to do this in Steps 18, 19 and 20. But that’s a story for later. If we have not selected **small group, self directed, self assessed PBL** as an important option, then consider other issues relating to student learning by going to Step 4.

Step 4. In learning subject knowledge we want to improve future recall by our students of knowledge learned To aid future recall, an option is to pose a problem first and help students to learn the new knowledge needed to solve a practical problem . One learning environment to use, but not the only one, is **small group, self directed, self assessed PBL** see Step 7. Table 4-1 gives suggestions on how to aid future recall for the students.

Table 4-1 Knowledge structure in Lecture versus PBL

	Conventional “lecture” style	small group, self directed, self assessed, PBL
knowledge structure	<ul style="list-style-type: none"> - pose problem first - teacher provides structure - use concept maps -use cause-effect diagrams - use elaboration 	- occurs naturally in this context
cues to connect problems to required knowledge	<ul style="list-style-type: none"> - need to emphasize this and spend time developing - concrete practical examples - bring in hardware, real problems 	- occurs naturally in this context

That addresses the development of knowledge structure. But what about improving student learning? Please go to Step 5, or to Step 7 if you have selected **small group, self directed, self assessed PBL**

Step 5. In learning subject knowledge we want to improve student learning. Principles to improve learning include:

1. Chickering & Gamson (1987) have given the following suggestions to *improve learning*:
 1. students are active
 2. students work cooperatively
 3. quality of teach-learn interaction
 4. students receive prompt feedback
 5. students have a clear time on task
 6. students work in an environment that expects success
 7. the learning environment caters to the student’s personal learning style
- and some additional suggestions include
8. assessment should be owned by the students
 9. there must be published goals/criteria
 10. attention span = 20 min
 11. students will wait 20 s before attempting to answer an question posed by the teacher
 12. we need to address knowledge, skills and attitude.

From a slightly different perspective Ramsden & Entwistle (1983, 1985, 1981) suggest that if we want to promote student’s “Deep learning” instead of “surface learning”, then the learning environment should be:

1. good teaching
2. openness to students
3. freedom to choose
4. clear goals & standards
5. vocational relevance
6. social climate
7. (-workload)
8. (-use of formal lectures)

Table 5-1 considers some of these suggestions and gives options to achieve these in the learning environment.

Table 5-1 Comparison between “Lecture” and PBL

Ideas to improve learning and to nurture “deep learning”.	Conventional “lecture” style	small group, self directed, self assessed, PBL
Active	Possible. Use - feedback lecture - cooperative learning, - “turn to a neighbour and...” - Talk Aloud Pairs Problem Solving	Occurs naturally
Cooperative	Possible. Use - informal cooperative groups - formal cooperative groups - study groups - criterion-referenced assessment	Occurs naturally

Ideas to improve learning and to nurture “deep learning”.	Conventional “lecture” style	small group, self directed, self assessed, PBL
Quality of teacher-students interaction	Challenging but - know and call them by names - take an interest in them as persons - attend student events - arrange in-class celebrations of student achievements.	For tutored groups, this is easier. For tutorless groups, this is more challenging than for “lecture”.
Prompt feedback	Possible but more difficult as class size increases. perhaps use peer and self assessment.	Occurs naturally.
Time on task	Easier because “you” are the manager.	Motivation helps to keep them on task.
Environment expects success	Needs special effort.	Needs special effort.
Personal style of learning	Possible.	Easier because of the small size of the group.
Students own assessment	Options available for students to own some or part of the assessment: - contracts; - students create part or all of the exam - self and peer assessment counts for part of the grade.	Occurs naturally in self-assessed.
Clear goals and criteria	Teacher provides; easy to do but the teacher must publish.	Training needed but should occur naturally; challenging because the student’s own it; monitoring needed.
Attention span 20 min	Teacher needs to limit “teacher talk” to 20 minute bursts.	Occurs naturally.
20 s response time	Teacher needs to help students overcome.	Overcome naturally because of motivation and small size of group.
Addresses knowledge, skills and attitude	Usually focuses on knowledge: need to provide development and opportunity to further develop. Self assessment, conflict resolution and change management are usually not included.	Opportunity to develop/ further apply the skills and attitudes. Often the tutor supplies these and students don’t acquire skills.
Freedom to choose:	Possible -use Branda’s PBEE (1993-95)	students empowered with the process; tutor guides and monitors.
Motivation	Possible.	High.

Ideas to improve learning and to nurture “deep learning”.	Conventional “lecture” style	small group, self directed, self assessed, PBL
Vocational relevance	Possible.	Occurs naturally if problems are selected with care.
Social climate	Possible to create.	Occurs naturally.

It is easier to achieve most of the characteristics that improve learning by selecting **small group, self directed, self assessed PBL** see Step 7. If lecturing is the preferred option, then each characteristic can be addressed separately. It’s possible. It is just more work. please go to Step 6 or directly to Step 7.

Step 6. In learning knowledge, we want to minimize student’s preference for rote or surface learning and shift to more emphasis on “search for meaning” or deep learning.

Research evidence suggests that learning environments that are primarily lecture (with teacher control) tend to encourage rote learning; the preference for deep learning decreases. Such environments are characterized by a low value of the Course Perceptions Questionnaire (or equivalent) with values 15 to 22. The use of **small group, self - directed PBL** environments that are student centered tend to encourage deep learning with rote learning decreasing. The Course Perceptions Questionnaire has values of 35 ro 45. Evidence from Woods (2000b), Coles (1985), Regan-Smith et al. (1994) and Woods Hrymak and Wright (2000e).

To encourage students to search for meaning and use deep learning practices, use **small group, self directed, self assessed PBL** see Step 7.

Step 7: We have selected **small group, self directed, self assessed PBL** as a learning environment to
a) develop lifelong learning (from Step 3). This approach does not do much to *build* skill in problem solving, communication, team work and self assessment (Woods, 1993a and b; Norman 1988, Norman and Schmidt, 1993, and Woods et al., 1997) However, this learning environment provides an excellent opportunity to bridge and extend the skills.

b) to aid future recall (from Step 4).

c) to improve student learning (from Step 5).

d) to encourage students to abandon a surface learning approach in favour of a preferred deep learning approach (from Step 6).

● But are the students ready? Perhaps use Perry’s instrument (see How to gain the most from PBL, *HTGTM*, Chapter 1, Perry, 1970, Felder et al., 2000 and Woods et al., 2000c). For **small group, self directed, self assessed PBL**, we would like all students to be characterized by Perry level 4 to 5. Students who are not ready may be characterized as being at levels 2 to 3.

Are the students:

- ready to accept the teacher’s role as coach instead of lecturer? see Woods (1998). If not, see Step 8.

- ready to accept their role of ownership of the learning process? If not, see Step 8.

- confident that they can succeed in student-centered activities? If not, see Step 8.

- skilled and confident in problem solving, team work, self-assessment, conflict resolution and communication? If not, see Step 2.

- knowledgeable about PBL? If not, then see Step 9.

If yes, then go to Step 10.

Step 8: Preparing the student’s attitude about their role in **small group, self directed, self assessed PBL** .

Use the Perry inventory as a diagnostic.

- run a workshop on managing change addressing the grieving process, stress and time management and building self confidence. see “Problem-based Learning: Resources to gain the most from PBL” Chapter B. MPS 5, MPS 17, MPS 11, MPS 49 (see also Woods et al. 1997a).
- use Chapter 1 in *HTGTM*.

Please go to Step 10.

Step 9: Helping students understand **small group, self directed, self assessed PBL.**

Some options include:

- show a video of students in **small group, self directed, self assessed PBL**
- Socratically run a session for 5 to 500 students to demonstrate the process.
- use *HTGTM* as a required text and work through it.
- run a workshop on “What is PBL?” see “Problem-based Learning: Resources to gain the most from PBL” Chpt B. Please go to step 10.

Step 10: Are the faculty ready for **small group, self directed, self assessed PBL?**

Perhaps use Woods’ “*My Role is..*” *questionnaire*, and consider dimension *E* in particular. This is reproduced in Table 10.1.

10.1 Are the faculty ready to become student-centered and empower students with tasks in the learning process? Data for college and university teachers in conventional programs show responses of 10.3 with standard deviation of 3.5 for item E, page 11, on a scale from 0 to 20. Ideally, we would want faculty responses > 10. If your value is not > 10, perhaps reconsider whether **small group, self-directed, self-assessed PBL** is an option for you. Return to Table 5.1 and consider how you might modify the “lecture” style to improve learning.

10.2 Are faculty ready to assume the role of coach? “Guide on the side” and not “sage on the stage”? If not, perhaps reconsider whether **small group, self-directed, self-assessed PBL** is an option for you. Return to Table 5.1 and consider how you might modify the “lecture” style to improve learning.

10.3 Are faculty ready to maintain standards by assessing the process instead of traditionally being the assessor? If not, perhaps reconsider whether **small group, self-directed, self-assessed PBL** is an option for you. Return to Table 5.1 and consider how you might modify the “lecture” style to improve learning.

10.4 Do faculty have confidence, skill and coaching ability in the process skills of problem solving, team work, conflict resolution, change management, astute questioning and critical thinking? If not, go to Step 3.1, 3.2 3.4 and consider having a series of workshops to train tutors. A possible outline for training sessions is given in Table 21.1. More on tutor training will be discussed in Step 23.

If students are ready (from Steps 8 and 9) and the faculty are ready, then please go to Step 11.

Step 11: Plan the curriculum for **small group, self directed, self assessed PBL**

For your context you might:

- convert the whole program to PBL, see Step 12.
- use PBL in one course in an otherwise conventional program, see Step 13.
- use PBL as part of one course in an otherwise conventional program, see Step 13.

Table 10-1: **My role is** Questionnaire, MRIQ (based on Magnesen, 1985; Paul, 1992 and Woods, 1991) Donald R. Woods, June 1997

The following 18 items are arranged with options (a and b or a,b and c). Each option represents a preference you may or may not hold. Rate your preferences for each item by giving a score from 0 to 5. (0 means you really feel negative about it or strongly about the other options. The scores for a and b, or a, b and c MUST ADD UP to 5 (0 and 5, 1 and 4, 2 and 3, 1, 2 and 2) Please do not use fractions.

I think my role as a teacher is:

1a. I have a basic conviction that I can make a difference.

2a. My role is to maintain high standards and fail those who do not make the standards.

3a. My role is to uncover material so that students understand.

4a. My role is to make learning fun.

5a. My responsibility is to teach subjects.

6a. Students must grow personally as well as intellectually

7a. Teaching, research, consulting are all opportunities to help others learn. The only difference is the client and the "class size". Undergraduate teaching and graduate research are a seamless continuum of learning.

8a. Teaching and learning are a two-way responsibility. If students fail its partly my fault.

9a. If students understand my presentation, they will automatically remember the material. Learning is rote memorization and recall of facts.

1b. People come to me with basic attitudes and they won't change.

2b. My role is to help each succeed and make the most of his/her abilities.

3b. My role is to cover the material in the curriculum.

4b. Learning is serious business. My role is to be well prepared.

5b. My responsibility is to teach people.

6b. The sole purpose of college is intellectual growth.

7b. Undergraduate teaching is the burden I must bear to allow me to do research.

7c. Graduate research is the burden I must bear to allow me to teach undergraduates.

8b. Learning is one-way; I do my thing, and it's up to the students to learn.

9b. Understanding is not remembering. Students and I need opportunities to see new concepts in perspective, to understand their limitations and to reach conclusions. Learning is active, independent and self-directed.

10a. Students should learn knowledge and the processes for working with that knowledge. Knowledge cannot be separated from thinking.

11a. The development of values is an integral part of my instructional plan. Values play a significant role in my student's future success.

12 a. Students should self-assess. My role is to ensure that the assessment process used by the students is valid. I consider the goals, criteria and the quality of the evidence.

13a. My role is design the whole learning process. The students just have to follow my design.

14a. I am a resource to help students learn; students have the principal responsibility for making and carrying out their own plans.

15a. My role is to help students with academic and intellectual issues. It's not my responsibility to get involved with their personal and social life. responsibility.

16a. I prepare the detailed learning objectives, the assessment criteria but publish general guidelines for the students; to do otherwise provides too much detail; it's overwhelming for the students.

10b. All students need to learn in college is knowledge.

11b. The development of values is the responsibility of the home and/or the religious component of the student's life. You can't measure "value" development; therefore, it is inappropriate to include this area in one's goals.

12b. Assessment of students is my responsibility. I create and mark all the exams that are used to measure student learning.

13b. My role is to empower students with all elements in the learning process: goals, choice of text, assessment...

14b. I am the source of knowledge. I have the advanced training to be shared with them.

15b. My role is to help students with academic and intellectual issues and to help them with personal problems.

15c. My role is to help students with academic and intellectual issues and to informally socialize and attend student events.

16b. I publish detailed learning objectives and assessment criteria.

16c. Students should prepare detailed learning objectives and assessment criteria. I monitor the process to ensure the standards are met.

17a. My role is to help them solve problems similar

to those they will encounter in professional practice.

18a. I teach new knowledge. My role is to present well-organized explanations expressed to match the student's learning style.

17b. My role is to ensure that they know the fundamentals. I use problems that help develop and test that understanding.

18b. All new knowledge bears some relationship to past knowledge. My role is to activate the past knowledge and help students see the relationship between the new and the old.

Scoring:

A.^{1,2,6,9}

1a _____	1b. _____
5b _____	5a. _____
6a _____	6b _____
10a _____	10b _____
11a _____	11b _____
15b+c _____	15a _____

TOTAL _____

B.^{1,9}

2b _____	2a _____
16b+c _____	16a _____

TOTAL _____

C^{2,3,6}

9b _____	9a _____
10a _____	10b _____
17a _____	17b _____

TOTAL _____

D^{2,3,6}

3a _____	3b _____
8a _____	8b _____
9b _____	9a _____
10a _____	10b _____
14a _____	14b _____
16b+c _____	16a _____
17a _____	17b _____
18b _____	18a _____

TOTAL _____

E^{2,6,7,9}

12a _____	12b. _____
13b _____	13a _____
14a _____	14b _____
16c _____	16a+b _____

TOTAL _____

F^{2,6,8,9}

16b+c _____	16a _____
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Step 12: Congratulations! Everyone in your department is shifting to **small group, self directed, self assessed PBL.**

This provides an opportunity to make the greatest impact.

- Check first that all faculty have bought in and are ready, revisit Step 10.

With the students experiencing all subjects/courses in this format,

12.1 We have great chance to integrate the student's learning across subjects.

12.2 We usually have sufficient faculty resources to have one tutor with each group of five to six students.

12.3 We can do a better job of formally preparing students to capitalize on their experience.

12.4 We can timetable student groups around limited experimental and laboratory equipment.

Please go to Step 14.

Step 13: Congratulations! You are not waiting for others. You are going ahead with something over which you have control- your course. You can introduce **small group, self directed, self assessed PBL** as a pilot project for a minimum of three weeks or three cases or you might convert your whole course to this format.

With the students experiencing **PBL** only in your course,

13.1 We have a limited chance to integrate the student's learning across subjects in our cases. (The implications are discussed later in Step 15)

13.2 Since we have classes of size > 5 students we either work Socratically with many groups of five students or we work with tutorless groups. (This will be discussed later in Step 17.)

13.3 We have to be creative in preparing students to capitalize on their experience. (This will be discussed later in Step 23.)

At this stage, however, we should start by identifying systems, setting goals, creating the problems and resources. Please go to Step 18.

Step 14: Identifying systems and setting learning goals for Phases in the context of a full PBL program.

● 14.1 *Identify systems:* Conventional programs consist of a series of subjects or courses that are taken in some sequence: Chemistry, Physics, Mathematics and so on. **Small group, self-directed, self-assessed PBL** consists of a series of problems (that require the application of some Chemistry, Physics, Mathematics and so on as needed). We can eliminate the narrow focus on subjects and integrate the knowledge around practical systems. The practical systems, and the learning objectives for these, are selected so that within the program the students will achieve the same knowledge objectives as they would have achieved in conventional programs. However, the selection of the topics in a subject is on a need-to-know basis; rather than on a learn it now and you'll see later why you need this.

For example, in Medicine the knowledge addressed might be (Hamilton, 1976):

Phase I: 10 weeks (10 problems) to introduce health care problems, universal concepts of structure, function and human behaviour, interviewing and clinical skills. (see p 9-5 in *HTGTM*)

Phase II: 12 weeks. the reaction of the body to stimuli and injury, how cells, tissues and the whole organism responds to inflammation, neoplasia, metabolic homeostasis, ischemia and behaviour.

Phase III: four sessions of each 10 weeks on each of the major body systems: 1) blood and gastrointestinal system, 2) cardio respiratory system, 3) neuroscience, locomotor system, psychiatry and 4) renal physiology and electrolytes, reproduction system and endocrinology.

Phase IV: clinical clerkship: 8 weeks medicine; 8 weeks surgery; 4 weeks family medicine; 4 weeks psychiatry; 4 weeks obstetrics and gynecology; 4 weeks pediatrics and 16 weeks electives.

Detailed examples have not been published in engineering but some illustrative themes might be

Phase I: 10 weeks (10 problems) chemical engineer functioning in society. problems of design, process improvement, product design, trouble shooting in a range of processes (to introduce mass balances, finances,

chemistry, analytical chemistry, biochemistry, statistics, sampling, environmental impact, legislation, safety, sampling, measurement and process control, mathematics, asking questions, data resources, consulting and team work).

Phase II: 12 weeks (12 problems) energy mechanical and thermal; idealized behavior.

Phase III: 40 weeks (40 problems): non-idealized behavior and a focus on separation systems, mixing/size change, reactions.

Phase IV: design, process improvement, trouble shooting apprenticeships.

From such an integrated view, we can then identify overall learning goals (for knowledge, skills and attitudes) for the Phases.

An example matrix worksheet is given in Table 14-1 with columns for the traditional “subjects” or “courses” in a program and rows for the “problems”. For each column we have a conventional listing of the learning objectives for each course. The various goals for “subject content” or for “essential concepts” are scattered throughout the column so that we address each objective in some problem.

Table 14-1 Matrix of traditional subjects and problems

Learning goals	Case	Traditional subjects or courses							
		organic chem	investment; finance	sampling statistics	environmental chem.	mass balances	analytical chem	physics	math
Goals for Phase	1	x, y	x	y	y	y	y		
	2								
	3								
	4								
	5								
	6								

● 14.2 *Decide on a suitable cluster of goals for a Phase or two-semester period.*

Consider all the knowledge, skills and attitudes and express these in relatively large clumps that relate to the Phases outlined in Step 14.1

Please go to Step 15.

Step 15. *Do we have the tutors for a full PBL program?*

Even though you have the whole program converted to PBL, sometimes we find we don't have enough faculty resources to have a tutor for each group of 5 to 6 students. A temptation might be to increase the size of the student group to 7, 8, 11, 15. Please resist the temptation. Work with tutorless groups. (More will be said about tutorless groups in Step 24.)

Hopefully since the whole program is all PBL we can have one tutor for each group of five to six students.

Here are some guidelines to decide on the number of tutors available and needed.

In a conventional program, the typical teaching load for faculty with extensive research/clinical responsibilities might be two, three-credit courses per semester (10 to 15 weeks). These might be one graduate course and one

undergraduate or two undergraduate courses. This would be about six contact hours per week. Therefore in a full PBL program, the expectation would be to lead one or two tutorial groups with three to six contact hours per week.

In a conventional program, the typical teaching load for faculty with no research or clinical responsibilities might be five, three-credit courses per semester or fifteen contact hours per week. Therefore, in a full PBL program the expectation would be four or five tutorial groups.

For example, in our Chemical Engineering Department about 12 full time equivalent faculty in a research intensive program would be available to handle our usual classes of 45, 40 and 30 students in our second, third and fourth years. For groups of five or six students, ten faculty would be needed to handle the undergraduate load.

As another example, with 100 students in each of three years would need about 30 research/clinical faculty for the undergraduate program; or 4 “teaching” faculty and 20 research/clinical faculty or, in the extreme, 12 “teaching” faculty and no research/clinical faculty.

(Tutor training will be discussed in Steps 18 and 21 with an example outline given in Table 19.1. We will look at the details of tutors, tutor training (and even tutorless groups) later.)

At this stage we have confirmed that we either can work with tutorless groups (because our faculty resources are insufficient) or tutored groups.

Now consider the weekly load for the students (and for the faculty) in a full PBL program. Consider this in Step 16.

Step 16. Exploring the weekly schedule in a full PBL program.

To make the discussion concrete, consider two options A and B.

In Option A, the students have 4 to 6 hours of contact per week that are typically spread out as a 2 h “Goals” meeting early in the week (to be introduced to the case, identify learning needs, contract with each other on topics) followed later in the week by a 2 to 3 h “Teach” meeting. Between the Goals and Teach meetings the students have two to three days to research, learn and prepare to teach. With this approach, the learning objectives per case would be modest. The group will handle about eight different cases in 10 to 12 weeks. Several cases may lead to sufficient learning goals that student groups will elect to use the same case for several cycles of goals-teach.

In Option A, the “teaching” tutor who handles five groups a week has 25 to 30 h of contact per week and the schedule might be as shown in Table 16.1.

Table 16.1 Option A with a “teaching” tutor handling five groups a week; the “research/clinical” tutor is shown in italics

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
am	<i>Teach 1</i>	Teach 4		<i>Goals 1</i>	Goals 4		
pm	<i>Teach 2</i>	Teach 5		<i>Goals 2</i>	Goals 5		
evening	Teach 3			Goals 3			

In Option B, the students have 2 to 3 hours of contact per week with “Goals” meetings alternating with the “Teach” meeting. Between the Goals and Teach meetings the students have a week to research, learn and prepare to teach. With this approach, learning objectives per case will be more ambitious. The group will handle three to five different cases in 10 to 12 weeks. Again, several cases may be used for several cycles of Goals-teach.

In Option B, the “teaching” tutor who handles five groups a week has 10 to 15 h of contact per week; the “research/clinical” tutor handles two groups a week with 2 to 3 hours of contact per week. The schedule might be as shown in Table 16.2.

Table 16.2 Option **B** schedule for a “teaching” tutor; for a “research tutor in *italics*”

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
am	<i>group #1</i>	<i>group #2</i>		group #4			
pm		group #3		group #5			
evening							

Option **B** with an in-depth consideration of fewer cases may be more attractive later in the program when students are familiar with the approach. Option **A** may be more approach early in the program when students need more prompting, guidance and frequent feedback.

From a faculty viewpoint, option **B** certainly requires less contact time per week and more closely resembles the contact time in conventional programs.

The results of this analysis help us decide on the scope of the problems to be created to match the learning objectives.

Please go to Step 17.

Step 17: Clustering the learning objectives and developing the problems for a full PBI program

In Step 14, we identified systems and suitable clusters of essentials goals for a block of 10 to 15 weeks. Based on the decisions made in Step 16, we may have selected

- 8 cases with a ½ week turnaround time between Goals and Teach or
- 3 to 4 cases with a one-week turnaround time between Goals and Teach.

Here is a simplified illustration of how we might proceed.

● 17.1 *Create the learning objectives for each problem*

Consider the use to Table 14-1 in the context of Chemical Engineering Phase 1, problem 1. For example, in option “x” the cluster of learning objectives might be:

- the organic chemistry for “ethylene”, chemical thermal and environmental characteristics; typical reactions and products that can be made from ethylene and the raw materials and reaction routes for its production and
- how to read financial statements.

Alternatively, for option “y”, instead of learning how to read financial statements, our learning goals might be to learn elementary statistics, sampling, fate of chemicals in the environment, environmental legislation, and mass balances.

● 17.2 *Create the problem case scenario.*

A common mistake made by persons just starting PBL is to focus first on collecting or creating the problems. We do not start with the “problems” (whether we create them, get them over the internet or purchase them from other programs). We create the problems to satisfy the learning objectives to be achieved. Step 18.1 must be completed before we create the problems.

Our initial attempt to create a problem to achieve the learning objectives for case “x” might be:

Esso plans to expand their ethylene plant. Some argue that this expansion will have a detrimental effect on their profit. You have been asked if you wish to invest in a stock purchase plan offered by the company.

For option “y” a problem statement might be:

Esso plans to expand their ethylene plant. Environmentalists are protesting this expansion. This expansion will have a detrimental effect on the environment. As a representative of the company you are to go to a public meeting addressing these issues.

These are possible first attempts. Some criteria for a “good problem” are (Dolmans et al., 1997, Alverno College, 1977) and Drummond-Young and Mohide, 2000):

1. the learning outcomes expected by the teacher are identified correctly by the students; the scenario contains “cues” that will trigger the desired search for learning objectives;
2. the learning outcomes are consistent with the stage of development and builds on and activates prior knowledge;
3. an appropriate level of complexity is included;
4. the scenario requires integration of knowledge, skills and attitudes across subjects;
5. the scenario allows an openness;
6. the scenario is motivational and relevant; the scenario is similar to one we might encounter in professional practice;
7. the scenario promotes student activity;
8. the scenario identifies the context, gives a concrete scenario and clearly identifies the expected task without spelling out specifics.

We use these criteria to polish, expand, alter the problem statement.

● 17.3 *Create the resources*

Based on the learning objectives, we can then identify, and make available, pertinent learning resources, laboratory equipment, resource experts. If we have limited laboratory equipment for the number of student groups, then we can give different groups different problems so that the laboratory equipment can be available for the students.

Please go to Step 20.

Step 18: Identifying the section, setting goals for the problems, creating the problems and the resources in the context of a single course of **small group, self directed, self assessed PBL** in an otherwise conventional curriculum.

● 18.1 *Identify the course or part of the course*

Consider, perhaps a three-week section of the course. Choosing less than three weeks provides insufficient time for students to adjust to and appreciate the new learning environment. Give your pilot program a chance to succeed!

Explore how we might overcome limitation 13.1 (limited opportunity to integrate across subjects). Is there any laboratory work, tutorial or project work that can be included to enrich the subject knowledge? Although we are limited in how extensively we can integrate the subject knowledge across the case, we can still try to bring in issues other than those we might traditionally have considered.

For example, if we selected a three-week section on heat exchanger characteristics from a traditional course of heat exchange, then we might want to:

- ensure that the knowledge is used in a context typical of what a professional encounters in practice. The “characteristics” of heat exchangers might be replaced by “rate” a heat exchanger, “select” a heat exchanger, “trouble shoot” unexpected behaviour on a heat exchanger.

- broaden the viewpoint to include operability of heat exchangers, thermal integration of systems, energy reduction, safety, ethics, engineering economics related to, operation of heat exchangers integrated with reactors, integrated with distillation columns and so on.

● 18.2 *Identify the learning objectives*

We have already published learning objectives and criteria for our traditional course. Reconsider these in the light of actions taken in Step 18.1. Cluster these into sets of objectives that can be achieved in about one week of PBL.

For example, for PBL activities in one course in an otherwise traditional curriculum, we need to work with short cases that can be achieved in a one week turn around. The first time I tried this I created a long case problem that would take three weeks to address. The students didn't do anything on it until the last week and then complained they ran out of time; the case was too big! Typically I now use one hour on Thursday for the "Goal setting" meeting. The students read the case, identify what they need to know to solve the problem, create learning objectives and contract with each other on the topics they will learn and teach. The "Teach" meeting is on Monday or Tues, for one to two hour. This means that each student has only from Thursday to Tuesday to research, learn and prepare to teach the knowledge. Considering the other commitments the students have to the other courses they take concurrently in a conventional program, I can expect them to do about three to five hours of "homework" per week. There will be four to five other people working on other topics. Since each problem has about five or six learning objectives, one student is expected to achieve one learning objective. Hence, cluster learning objectives in packages of about six to seven for each week of PBL activity.

● 18.3 Create the problem case scenario

Some criteria for a "good problem" are (Dolmans et al., 1997, Alverno College, 1977) and Drummond-Young and Mohide, 2000):

1. the learning outcomes expected by the teacher are identified correctly by the students; the scenario contains "cues" that will trigger the desired search for learning objectives;
2. the learning outcomes are consistent with the stage of development and builds on and activates prior knowledge;
3. an appropriate level of complexity is included;
4. *the scenario requires integration of knowledge, skills and attitudes across subjects;*
5. the scenario allows an openness;
6. the scenario is motivational and relevant; the scenario is similar to one we might encounter in professional practice;
7. the scenario promotes student activity;
8. the scenario identifies the context, gives a concrete scenario and clearly identifies the expected task without spelling out specifics

We usually have to relax criterion #4 "the scenario requires integration of knowledge, skills and attitudes across subjects" unless we have been able to overcome this limitation in step 18.1.

● 18.4 Create the resources

This may be your published critique of the major texts, copies of key articles made available in the reference section of the library and copies of your transparencies or internet materials you used when you taught the course in a traditional format.

Now consider how best to handle the tutorial task.

Please go to Step 19.

Step 19: Tutors for PBL in a single course in an otherwise conventional curriculum.

As pointed out in 13.2 since we have one instructor with classes of size > 5 students we either work Socratically with many groups of five students or we work with tutorless groups.

19.1 *Work Socratically.* Assign students to groups of five. Lead all the groups in one large room through the process by alternately assigning a task, gathering the results, responding to the results and reassigning a task. This is still **small group, self-directed, self assessed PBL** but the tutor is shared with all groups. A description of this approach is given in "Problem based Learning: Resources to gain the most from PBL," p A-19 to A-23. The challenge with this approach is monitoring the self-assessment. Some ideas on how this might be done will be given in Step 25.

19.2 *Use tutorless groups.* (This will be discussed in Step 24.)

We will look at the details of working with tutorless groups later. Now we need to consider the development of the process skills.

Please go to Step 20.

Step 20: For both partial and full PBL programs, select **what** process skills are needed for **small group, self directed, self assessed PBL**

In Steps 2 and 3 we discussed skill development as dictated by the desired outcomes for the program. However, for **small group, self directed, self assessed PBL** our needs for process skills are clear. Table 20-1 summarizes the skills, an idealized approach to development and my estimate of the minimum.

Table 20-1 Process skills for **small group, self directed, self assessed PBL**

For	skill needed	idealized number of workshops	minimum commitment
small group,	interpersonal skill group skill conflict resolution assertiveness chairperson	MPS 52 (2 h) MPS 28 (4 h) MPS 45 (3 h) MPS 47 (2 h) MPS 29 (15 h)	Modified MPS 52 (30 to 50 min) p. B-24 ff. Resources Modified MPS 28 (60 to 90 min) p. B-30 ff. Resources
self directed,	self confidence goal setting (self assessment) teach skill critical thinking	MPS 1, (2 h) MPS 11 (3 h) MPS 31 (3 h) MPS 3 (6 h)* MPS 36 (3 h), MPS 12 (4 h) MPS 30 (4 h)	Modified MPS 36 (90 min) p B-38 ff. Resources
self assessed	self assessment	MPS 3 (6 h)*	Modified MPS 3 (70 to 90 min) p B-48 ff. Resources
PBL	problem solving: strategies, awareness, creativity elaboration	MPS 1 (2 h) MPS 4 (4 h) MPS 7 (8 h) MPS 14 (2 h)	Modified MPS 4: (90 min) p B-16 ff, Resources and p. 3-23 activity 3.2 in HTGTM
	The MPS program is described in http://www.chemeng.mcmaster.ca/innov1.htm and click on MPS.		The goals, transparencies and timing sheets for the modified workshops are given in “Problem Based Learning: Resources to gain the most from PBL”

How to use the data in Table 20-1 depends on whether we work with full PBL programs (discussed first) or with PBL as a course in an otherwise conventional program (discussed second).

● 20.1 For full *small group, self directed, self assessed PBL* programs:

I recommend that *tutors* receive the full training as outlined in column 3. Tutors usually possess these skills intuitively but most lack confidence in how to *coach* others and how to *assess* the skill of the students. This reminds me of a call I received. “We have failed a student based on her “poor” problem solving skill. We know she lacks the skills but we are unsure as to how to provide feedback to her about her deficiencies.” Once tutors have received these workshops (or even mentally worked their way through the workshops) tutors know what the skill is, how to describe, how to assess the skill and how to give feedback to students about their skill.

In addition tutors should gain confidence in how to prompt students. This is discussed in Chapter 2 in *Helping*, “Problem based Learning: helping your students gain the most from PBL” that can be downloaded free from <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL.

For *students* in full PBL programs, I recommend that the students receive at least the minimum skill development program listed in column 4. Actually, I prefer to give students as much training as possible from column 3.

For tutored groups, that are possible in full PBL programs, the tutor can play a vital role in the skill development. Indeed, some options used in different programs include:

- a) Train the tutor and depend on the tutor to supply the process skills. Do not expect skill acquisition by the students. This is contrary to Step 1 and I do not recommend this approach.
- b) Train the tutor and trust that through feedback and modeling the students will acquire the process skill. I believe that more structure is needed to develop the skill and confidence in the students.
- c) Train the tutor, use *HTGTM* or equivalent as a required text and work through the text.
- d) Train the tutor and recommend *HTGTM* or equivalent as a resource.

Although a to d are options that have been used, my bias is that students should explicitly experience the minimum skill development by workshops, as outlined in column 4 of Table 20.1.

Please go to Step 21 to address the question of **when** to develop these skills for students in a full PBL program.

● 20.2 For *small group, self directed, self assessed PBL in one course in an otherwise conventional program*

The teacher/tutor should receive the full training described in column 3 of Table 20.1.

The students should receive the minimum in column 4 and as much of column 3 as possible. Empowering the students with these process skills is very important because the student groups will be working autonomously without a tutor. They cannot count on a tutor to help them resolve conflict, create learning goals, have an effective group, systematically solve the problem; they should have the skills to do this themselves.

Please go to step 22 to address the question of **when** to develop these skills for students in a single courses in an otherwise conventional program.

Step 21: For a full PBL program, select **when** to address the process skills and getting students ready for **small group, self directed, self assessed PBL**.

Since all students in the program need “process skills” for PBL, we can formally prepare students as part of the program goals and outcomes. Here are some options:

21.1 *Pre-screen* students and **admit only** those who can demonstrate skill. This approach is taken by McMaster Medical School. The pre-screening is done with applicants working on a problem in a simulated tutorial. Three trained observers rate the problem solving and group skill of each of the seven applicants being observed.

Table 21-1 Suggested outline for a week-long, pre-PBL workshop (from **Helping**, p. 6-5)

Time	Topic	Comments and resources
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Day 1: am 20 min	Overview to process skills; importance in life and for PBL;	List names of skills: problem solving, group process, interpersonal skills, self-directed learning, shift from dependent to independent to interdependent learning, self-assessment; rationale for why skills are important, the challenge in developing them; Resource: Section 3.4 of this book. MPS unit 2 and "The MPS Strategy Book".
Day 1: am 3 h rest of morning	Awareness of "what goes on in our mind"	Workshop using Talk Aloud Pairs Problem Solving; sometimes may be omitted and participants go directly to the talk-aloud strategy workshop. Otherwise, this is a prerequisite activity for the Strategy workshop. Resource: MPS Unit 1 and "the MPS Strategy Book". Resources Section C.3.
Day 1: pm 4 h	Strategy workshop	Workshop using Talk Aloud Pairs Problem Solving with the problem solver moving a marker to show the "stage" that they are addressing. An extremely simple and powerful workshop. Resource: Exercise 3.2 in HTGTM . MPS Unit 4 and "the MPS Strategy Book". Resources Section B.3.
Day 2: am and pm 7½ h	Creativity workshop	Helps students brainstorm issues, create hypotheses. Often handled in other programs through a 10 to 30 min introduction to the principles of brainstorming. We have found this to be insufficient to actually develop confidence and personal skills. Resource: mentioned in Chapter 3 in HTGTM . MPS unit 7 and the "MPS Idea Book".
Day 3: am 3½ h	Change and stress management	Addresses one of the most important attitudinal issues in PBL. Can be tied to topics of "time management". Can be handled as topic by itself or intimately connected to the short-term goal of PBL. Resource: contact your local mental health association and ask them to facilitate the workshop. Or use Chapter 1, HTGTM ; Others resources include MPS 5 and 17 on time management.
Day 3: pm 4 h	Criteria and decision-making	Needed for assessment, for goal setting, for defining problems and for any evaluation or judgement. Resource: Chapters 3 and 9, HTGTM . MPS 23 and 24 and "The MPS Idea Book".
Day 4: am 3½ h	Self-assessment	Even if the tutor will do much of the assessment, helping the students understand the issues of assessment is vital. This also is a nice extension of the previous topics of criteria and decision-making. Resource: Chapter 9, HTGTM . MPS 3 and Chapter 5 in "The MPS Idea Book".
Day 4: pm 4 h	Group skills	Important set of workshops in which one includes as much experience as the students have time for. You might wish to start with activities on interpersonal skills and listening. Although you will not be able to move the group all the way to team behaviour in the limited amount of time, you will be able to plant seeds that will guide future behaviour. Resource: Chapter 5. In particular Exercise 5.5, HTGTM . MPS 27, 29, 45 and 52.
Day 5: am 3½ h	Group skills, chairperson skills	
Day 5: pm 3 h	Teams and team building	
Day 5: pm 1 h	Wrap-up, summary	

21.2 *Develop* the skills in explicit skill development workshops **before** the first semester begins. An example outline of such a training program is given in Table 21-1. This training can be for tutors and we recommend that it be used

for all students in the program. (The Nursing program at McMaster University uses a half-day workshop on change management, stress management, understanding PBL and problem solving strategies on the first day for all students. An outline of these workshops is given in “Problem-based Learning: **Resources** to gain the most from PBL,” Chapter B.)

21.3 *Develop* of the student’s skills **concurrently** with the first PBL cases but the emphasis is on “process skill” development. Koza (2000) describes a PBL program in Health Sciences in Japan where the emphasis at the first is about 80% on process skill development. This tapers to about 20% emphasis on process skill development near the end of the program.

21.4 *Develop* the skills of the students **concurrently** but with equal emphasis on process skills and the knowledge being learned. This was the approach taken in McMaster University’s Theme School program on “New Materials and Their Impact on Society” (Woods, Hrymak and Wright, 2000). This is illustrated in Table 21-2 and 21-3. Two versions are given that depend on the extent of skill development selected.

Please go to Step 23 if in Step 15 we have sufficient faculty for a tutor for every group.

Otherwise with tutorless groups please go to Step 24.

Step 22: For an individual course, select **when** to address the process skills and getting students ready for **small group, self directed, self assessed PBL**. This also applies for Socratically facilitated PBL (discussed in Step 19.1).

With a single course, we are restricted in how much time is available to develop the process skills and get the students ready (as discussed in Steps 8 and 9). The options are:

22.1 Use some tutorials **ahead** of time to get the student’s attitude ready (as discussed in Steps 8 and 9) and to develop problem solving and group skills (modified MPS 28 and modified MPS 4 listed in Table 20-1, column 4).

22.2 Build the skills **concurrently**. Blend the skill development with the PBL activity as outlined in Table 21-2 or 21-3. In this approach we start a PBL case problem in the subject domain and expect the students to have a Goals meeting followed by a Teach meeting. While this is happening, we take some of the in-class time and run a process skill development activity. Each PBL unit takes about a week. The version shown in Table 21-2 takes seven weeks of elapsed time. The version shown in Table 21-3 is less ambitious and takes four weeks of elapsed time.

Please go to Step 24 to see how to handle tutorless groups.

Step 23: Being a tutor in a group.

Having a tutor in each group of five to six students is usually only possible for a full PBL program where there are sufficient faculty resources.

Small group, self-directed, self assessed PBL requires skill in interpersonal communication, problem solving, team work, conflict resolution, stress management, change management, critical thinking, elaboration, assessment and teaching. Tutor training in the process skills has been discussed already in Step 20.1.

Tutors should gain confidence in how to prompt students. This is discussed in Chapter 2 in *Helping*, “Problem based Learning: helping your students gain the most from PBL” that can be downloaded free from <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL.

The main issues to be addressed in tutored groups tend to be (Woods, Hall, Eyles, Hrymak and Duncan-Hewitt, 1996):

Table 21-2 Building up the process skills concurrently: long version

	General focus	Skills and attitude addressed with MPS unit				
		attitude	problem solving	group skills	self assessment	self directed learning
PBL 1	adjusting	Perry, change, MPS 49				
PBL 2	awareness of processes		strategy workshops, MPS 4	interpersonal MPS 52; groups MPS 28		importance of feedback
PBL 3	goal setting		how to define. MPS 31		importance of goals. MPS 3	learning goals. MPS 36
PBL 4	self-talk	anger, stress, time management MPS 17, 5	creativity. MPS 7	anger, MPS 52		
PBL 5	criteria		decision making MPS 24		criteria MPS 3	criteria MPS 23
PBL 6	self-management	uniqueness, MPS 11; time management, MPS 17	exploring issues. MPS 15	cope with conflict. MPS 45		
PBL 7	knowledge structure		decision making by consensus	chair MPS 29		teach vs talk; cues

Table 21-3 Building up the process skills concurrently: short version

	General theme	Skill and attitude development with <i>Resource</i> material				
		attitude	problem solving	group	self assessment	self directed learning
PBL 1	adjustment	mini MPS 49, Perry and what is PBL?				
PBL 2	problem solving		mini MPS 4			
PBL 3	group work			mini MPS 28		
PBL 4	self directed learning					mini MPS 36

- breadth versus depth. helping the groups select just the right amount of depth to be learned.
- addressing emotional issues brought to the problem from personal experience that tends to cloud the search for the

real issues.

- the quality of the critical reasoning: helping the students to develop these skills
- dominance/passiveness: being able to create an environment where all students are comfortable sharing and contributing.
- astutely drawing on the background experience that students bring to a case but not allowing one with a strong background to dominate.
- encouraging the required reflection and elaboration after the problem has been “solved”
- getting students to self assess based on evidence rather than try to negotiate.
- lack of closure:
- dealing with overly negative or difficult behaviour
- skill in using the resources.

Some suggestions are given by Woods et al. (1996) about how to cope with these.

Please go to Step 25.

Step 24: Working with tutorless groups.

Our experience has been that tutorless groups function exceptionally well.

The main issues to be addressed in tutorless groups tend to be (Woods, Hall, Eyles, Hrymak and Duncan-Hewitt, 1996):

- apparent conflict because all members are not seen as pulling their fair share of the work (see also Woods, 2001e)
- attendance
- trust and reliability
- different work goals and standards among different students that leads to conflict.
- the amount of reflection, monitoring and writing they must do in self assessment and accountability.

Some suggestions are given by Woods et al. (1996) about how to cope with these.

Please go to Step 25.

Step 25: Making it all work: assessment and accountability.

Whether working in tutored groups or tutorless groups, we are empowering students with the tasks of setting standards, assessing progress, developing trust and working effectively together.

Our experience has been that by underpinning the whole process with the principles of assessment makes PBL effective, efficient and hassle-free. Those principles are:

Principle 1: Assessment is a judgement based on performance - not personalities. We need to help a student realize that a poor mark does not mean he/she is a bad person. The judgement is made about performance in completing a task. It has nothing to do with his/her value as an individual. This is an issue, especially for students with attitudes characterized by Perry’s level 2. More details about Perry’s levels and their implications to teaching and learning are given elsewhere. (see How to gain the most from PBL, *HTGTM*, Chapter 1, Perry, 1970, Felder et al., 2000 and Woods et al., 2000c.)

Principle 2: Assessment is a judgement based on evidence - not feelings. We might intuitively feel that a student is skilled at team work. However, we need to replace that intuitive feeling with physical written evidence.

Principle 3: Assessment should be done for a purpose with clearly-defined performance conditions.

Principle 4: Assessment is a judgement done in the context of published goals, measurable criteria and pertinent, agreed-upon forms of evidence.

Principle 5: Assessment should be based on multidimensional evidence: static and dynamic situations; small assignments and lengthy projects; academic, social and personal contexts; under a variety of performance conditions (exams and homework, written and oral, performance as an individual and as a member of a group), formative and summative data and with different persons being the assessors (self, peer, teacher and trained external observers).

More about how to use assessment to aid **small group, self directed, self assessed PBL** is given in:

- Chapter 5, of **“Helping your students gain the most from PBL”** that can be downloaded free from <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL.
- Chapters 8 and 9 of **HTGTM**
- Woods “Assessing lifelong learning skills,” Chem Eng. Education (2001a).

Please go to Step 26.

Step 26: Looking after the nitty gritty for both tutored and tutorless groups.

You’re almost ready to go. Consider the issues in Chapter 4, “Issues in Setting up **Small group, self-directed, self assessed PBL**” in Helping your students gain the most from PBL” downloadable free from <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL.

ENJOY!

Acknowledgments:

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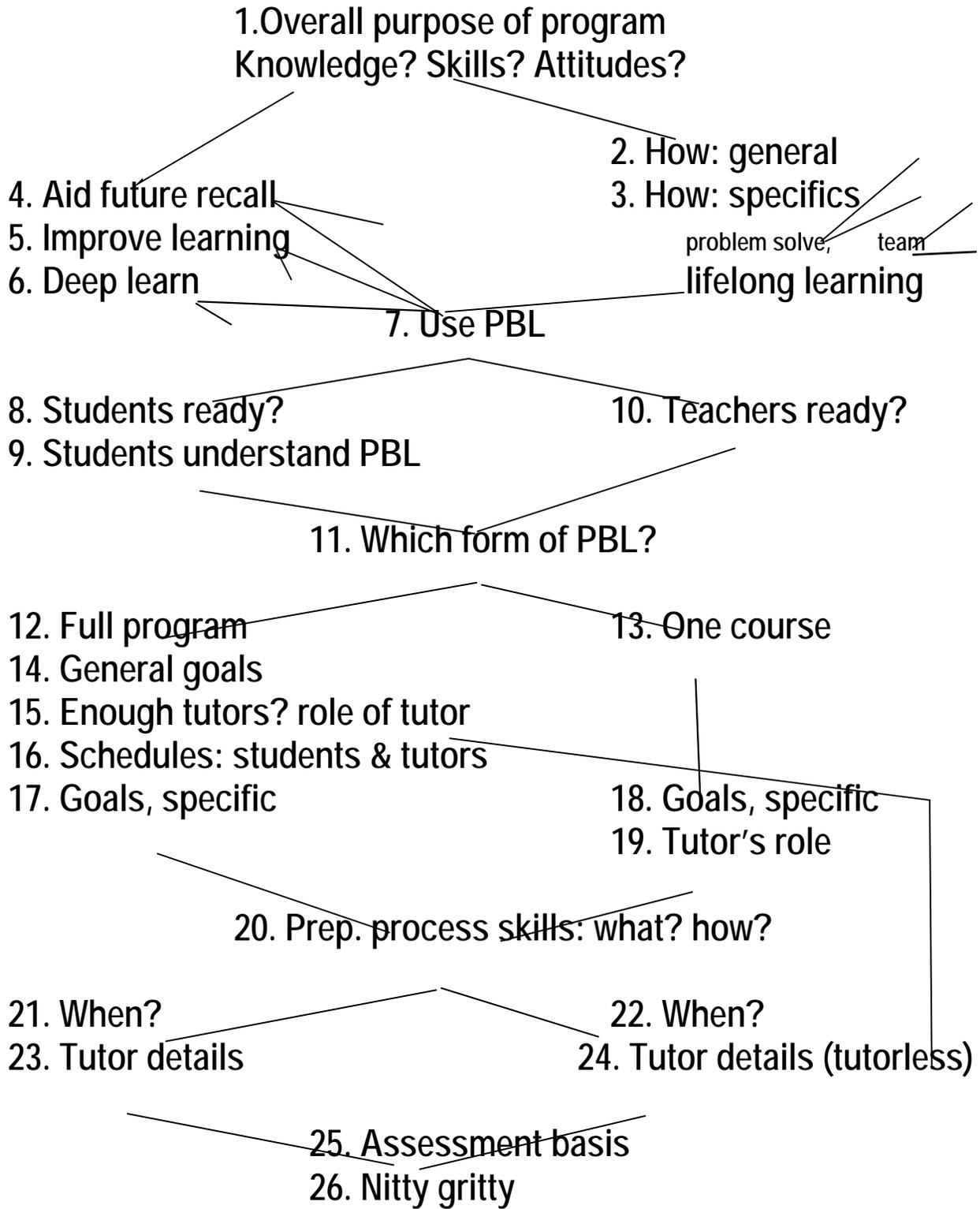
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PBL: when? who? where? what? how? c:\pbl

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5. Implementing PBL

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McMaster University, Hamilton, Canada

The learning experience must be designed to take advantage of the strengths of PBL: active, empowering yet accountable, cooperative, just-in-time learning, positive environment expecting success, prompt feedback, developing of maturity and confidence and developing process skills (especially lifelong learning). You will have a different role as monitor and mentor (guide on the side) with your major effort being spent creating the learning environment to provide structure, structure, structure without interfering with the process.

So how to start?

Step 1. For the full program: list the knowledge, attitudes and skills possessed by your graduates. *Example, “skill in lifelong learning, team work, self assessment..”* Publish these in the calendar and in the course outline, syllabus for each individual course.

For an individual course, list the knowledge, attitudes and skills possessed by the graduates of your course.

Step 2. For the full program, agree on the definitions, learning objectives and forms of evidence for each process skill. Use the same criteria and form throughout the whole program. *Example, “The form to assess oral and written communication skills for all activities in our program is....”*

For an individual course, don't reinvent the wheel. Select published data. For example, see Chapter 3 of Woods, “PBL: helping your students”, Chapter D of Woods’ “PBL: Resources..” and <http://www.chemeng.mcmaster.ca/innov1.htm> and click on MPS for the process/professional skills.

Step 3. For the full program, identify for each course where those skills will be developed initially and used consistently throughout the program. *Example, “team skills will be developed in Course 950, used in course 1015,...”* This information is used by the Department to plan the curriculum.

For an individual course, tell your colleagues about what you are doing so that they can use the skills your students are acquiring. They can use this information to help other instructors with their own courses.

Step 4. Reduce the amount of subject knowledge “covered” in your traditional lecture course by 1/4 to 1/2. Initially this may appear to be an impossible task. However, my experience has been that in any course the task is relatively easy when we scrutinize the current “coverage” based on the criteria of

1. What fundamental ideas from this course will still be pertinent in the year 2015? Will technology have changed?

2. What must the students know to take the subsequent courses?

In any course I find that there is the core but there also are "the instructor's favorite ideas". Nothing wrong with the latter but we need to focus on the fundamentals.

[This is easier to do when the Program is considering all the courses in the program. There usually is a lot of overlap and repetition. You can also take 2 credits of stuff from one course and combine it with 1 credit from another. On the other hand, if you are the only one making the change and it is in your course, then you have more constraints... but you can do it.]

The reason we need to “reduce the subject knowledge” is that time must be allowed to develop, and assess the process skills and attitudes being developed.

Step 5: Try to arrange for two 75-minute sessions per week instead of the traditional three 50- minute lectures per week. The University of Delaware has found this to be extremely helpful. One the other hand, at McMaster we were constrained to three 50-minute sessions per week and we could make PBL work. Also, we had two 100 minute sessions per week to develop the process skills. Try to have class in a room with a flat floor, moveable chairs and tables (instead of a traditional banked auditorium). If your class size is 60 students, arrange for a room “with seating capacity” for 90 to 100.

Step 6: Create the problems.

First the problems must achieve the target “learning goals”

1. the learning goals are achievable. For single courses (for example in hybrid or conventional programs) for each problems allow about 3 to 5 hours of study for an individual student; each problem would have about 6 to 10 objectives for a group of 6 students so that each will research/teach the others.
2. the learning outcomes are consistent with the stage of development and builds on and activates prior knowledge.
3. goals might integrate knowledge, skills and attitudes across subjects and disciplines.

The problems must represent “professional practice” and must contain “cues” that will direct the student to select “your learning objectives for the problem”

About the scenario created. (can be a single scenario, or you could build a sequence of scenarios but each would expect the same 3 to 5 hours of student study).

4. the scenario contains “cues” that will trigger the desired search for learning objectives; the learning outcomes expected by the teacher are identified correctly by the students.
5. the scenario includes an appropriate level of complexity.
6. the scenario allows an openness. This challenges the student’s thinking and expects the student to integrate the new knowledge with the old.
7. the scenario is motivational and relevant.
8. the scenario is similar to one we might encounter in professional practice; (for example, in Engineering this might include rating, debottlenecking, design, trouble shooting, labour relationships, team work, public, monitoring compliance with legislative regulations).
9. promotes student activity.
10. any data given should be raw data (like we encounter in practice).
11. the scenario identifies the context, gives a concrete scenario and clearly identifies the expected task without spelling out specifics.

- Example Case 6 Paul’s decision

Context: Lifelong learning course to first year students at City University of Hong Kong

Target Objectives:

Setting priorities
 Managing time
 Budgeting time
 Clearer understanding of the expectations in university for time to study
 Long and short term planning
 Procrastination
 Learning to say No!

Paul’s decision (Ed Ko, City University of Hong Kong)

Paul has been persuaded by his friends to run for a position on the Departmental Society. He really would like to, but he is afraid that doing so might take time away from his other activities. He is already on the university swimming team and has to work five hours a week in order to earn some money to pay back his credit card loans. With six courses that he is taking this semester, he feels that he is constantly behind in his work.

Suggested approach:

1. Consider working with 4 week’s worth of “learning” or 12 hours of “lecturing”
2. For *that portion* of your course gather the following materials together:
 - A. the learning objectives (For example, there should be about 20 to 30).
 - B. your lecture notes for those 12 hours.
 - C. the usual homework assignments you give (For example, this might be about 4 assignments [one per week] with about 4 questions each assignment. These may not be very helpful because most “textbook assignments” give information that is not usually given in professional practice (criterion 8, p 5-2) and we will ultimately have to create four PBL “problems” whereas you had 16 homework problems).
3. Try to divide the learning objectives, lecture notes, typical problems into four different *package*. That is because we are replacing the four weeks of lectures with four PBL problems to be handled one problem per week. (Or

alternatively one series of problems that has four parts, eg. Case 9, *Tony LoPresti*.)

4. Once you have a *package* representing one week's worth of work (or one case problem), write down about 6 to 8 learning objectives, each of which would require a student to spend about 5 to 8 hours to research, understand and prepare teach notes.
5. For this subject knowledge, think of several professional situations which your graduates might encounter where they would need to know this subject knowledge. For each situation, start to frame a brief story. Often it helps if you have a conversation between two or three people.
6. Set your description of the situation aside and leave it for several days. Then return and reread it. Think carefully about the relationship between the description and the learning objectives. Is it going to be very easy for someone to create a learning objective from the story, or do we have to add many *cues*?
7. The problems should:
 - build on knowledge and activate knowledge they know already (criterion 2)
 - should be motivational, interesting, something a student will want to work on (criterion 7)
 - must be representative of what you would encounter after the student graduates (criterion 8)- List your learning objectives.
8. Give your results to a student (or colleague) and ask them to brainstorm the learning issues. Usually they will only be able to identify 60% of your objectives. Explore what additional cues might have helped them retrieve your objectives.

Step 7: Visualize the timing and the meetings.

Must have at least Two meetings;

Meeting #1: Goals meeting: where students interact with the problem, generate learning objectives, get validation from the tutor that their learning goals are "correct", contract with each other about the learning/teaching each will provide. *Example "validation form" attached. see p 3-22*

Meeting #2: Teach meeting: when students teach each other, use the information to solve the problem and elaborate about how and when this new knowledge can and should be used. *Example feedback form attached. see p 3-21.*

Woods adds a third meeting (after the Teach meeting) Meeting #3, the Feedback or exam meeting when students pose exam questions to other groups.

If students, and you, do not have confidence that all the students will be teaching the correct stuff, then try a Jigsaw meeting in between the goals and teach meetings, Meeting #1b. Since all groups have the same core objectives, probably one person from each group will have contracted with the group to teach topic A. Bring together members from all the groups that have researched and will teach topic A to consolidate understanding.

Step 8: Organize the student groups. Assign students to groups of 5 to 6. These groups will remain the same for the semester (10 to 15 weeks depending on your program).

Step 9: Create the resources. Publish a guide to locations of the information to be learned. Alert the Library.

Step 10: Think about options for assessment of knowledge learned.

- Student summary of the quality of knowledge learned.
- Group solution to the problem.
- Individual concept maps of the knowledge.
- Individual Test and Exams of the knowledge, TETK. created by teacher, peers, groups, individuals, self.
- Individual teach notes and learning contract.
- Peer assessment of the quality of the knowledge brought to the teaching task.

Assessment of process skills: see series of papers in Chemical Engineering Education “Assessing problem solving skills”, “Assessing team skills”, “Assessing lifelong learning skills.”

Step 11. Develop the process skills see <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL for overview and click on MPS for details. see also paper PBL: Decisions for Planning and Action: why? when? who? where? what? how? see also the workshops given in Woods “PBL” Resources to gain the most from PBL”.

Step 12. Plan for Success!

Include activities at the beginning to help the students realize why you selected PBL as the learning environment, bring in success stories, help them see the new roles expected of them and the new role you will be playing. Use Perry’s questionnaire to help students identify their current attitude about the learning environment. (see Woods, “PBL: how to gain the most from PBL” Chapt 1). Use class ombudspople to monitor the learning environment throughout the year. Be flexible and respond to their concerns. For more see Workshop #5.

Step 13. Add structure for assessment

Students expect us to be fair. Because cooperative group activities are used, students usually feel that their group will have slackers who do not do their full share of the work. They seek assurance that somehow you will know what is going on in their autonomous group. You can! By the use of assessment forms for about every task the student does you can gather evidence that will help you understand what is happening and that can be used by the students as evidence for assessment.

A range of assessment forms have been developed and are given in the book Woods “Problem-based Learning: how to gain the most from PBL” and as handouts from these workshops.

Step 14. Add structure to develop self confidence.

Bandura (1982) studied self confidence, what it is and how you develop it. He found the following differences between self confident persons and those who had little self confidence.

Self confident	Low self confidence
Prepare	Avoid
Focus on the “tough stuff”	Hope it doesn’t happen
Persevere	Give up
Manage stress	Stress debilitates
Focus first on the familiar	Focus first on the “strange”
Positive self talk	Negative self talk

He found that an environment to develop self confidence provides rewards for performance; highlights the positives achieved because those with low self-confidence will tend to become despondent and self-devalue. The presence of highly competent individuals undermines the effective use of routine skills by others.

To develop self confidence Bandura (1982) recommended enactive mastery via workshops > observe models perform the task > emotive strategy to tell yourself you can do it > cognitive strategy. Stress is related to self confidence. We have found that helping individuals identify their “uniqueness” is very helpful. Training students to self assess is another activity that increase self confidence. In general, the stages in developing self confidence might follow the following pattern:

- Self awareness.
- Aware of what others do.
- Acceptance of self and others.
- Cognitive and attitudinal shifts related to stress management: positive self talk, learn to say NO; worry about what have control over; sense of being in control; willingness to risk
- Attitude about assessment. Receiving \pm and responding to feedback. (Perry level 5)

- Aware of models of behavior: observe, and become aware of the *target skills*.
- Successfully complete achievable goals posed by others with +ve feedback from others (as is done in workshops).
- Set achievable goals and self assess.
- Self confidence

Use these ideas in planing your PBL learning environment.

Step 15. Include reflection and elaboration.

Elaboration is the process of creating a new perspective and relating new ideas to previous ones. According to Schmidt (1983) elaboration is one of the more effective ways to “learn”. Elaboration includes activating previous knowledge and searching for connections between previous and new knowledge. Elaboration includes determining the details of the new knowledge, creating examples, analogies, restatements, conditions, deductions and simplifying and generalizing. Elaboration includes searching for similar concepts and noting confusing elements, similarities and differences.

Reflection is process of thinking about what you have experienced in the past; include knowledge, attitudes, feelings, reactions of what you did and what others did, felt, responded.

Step 16: Consider how to evaluate your program’s effectiveness

The changes you make should make learning easier and more effective for your students. In the design of your course, think about how you might gather evidence to prove this.

Enrichment:

1. Please help me understand how best to help you
2. MRIQ
3. Feedback forms: 3601 student teaching effectiveness in PBL
 - Goals identification;
 - Learning preference table
4. Ten example goals and problem statements (some excellent, some fair, some poor)

References:

Woods, “Problem-based Learning: helping your students gain the most from PBL” Chapter 4 downloadable

● Case 2: Letter **to** the Dean:

Context: education in PBL

Target learning objectives:

student-teacher mismatch:
 - learning style MBTI
 - Piaget: theory vs concrete
 - Perry: student vs teacher expectation
 lack of clear goals and criteria
 teacher attitude
 student's reaction to change
 lack of mentor for teacher

criteria for tenure:
 - solely on student evaluations
 - 3 peer reviews of course outline
 - teaching dossier
 - evidence of 1/3 course revision
 - evidence of scholarship vs diddlin' around

need to inform others: dean, students, chair, peers.

The letter to the Dean.

You have been five years in a tenure-track position. You have 15 refereed publications with 4 others in the mill. You have 2 Master's students and 2 PhD students plus a large series of grants to keep your research program viable.

Your teaching has received "fair" ratings from the students in the past. last year the Chair suggested that you might devote a little time to improving your teaching. Indeed, the Department sent you on two workshops: one on cooperative learning and the other on PBL. These were very motivating. You saw that you could introduce PBL to part of your course 393. You added cooperative learning to each tutorial and you took a four week section of the course and converted it to PBL. It is now six weeks into the term. The Dean invites you to see him and gives you a copy of the following letter:

Oct 15

Dear Dean Habizz

We the undersigned represent 82% of the students in Course 393. The professor is incompetent! The professor is not doing the job. The professor should be fired. We are paying big bucks to come to this university. We demand that you replace this teacher with one who knows how to teach.

H. Andre; A. Sabina; R. Gottz; F. Goamm; R. Jones; K. Sigvaler K. Armstrong; A. Siggs; P. Scripps; B. Carruthers; Z. Gafter; H. Dominik and many many other signatures

● Case 3: Letter **from** the Dean:

Context: education

Target learning objectives:

What is PBL?
 advantages vs disadvantages:
 time: can I gradually move toward
 form of PBL for my situation: how many instructors? how many students?
 mine the only course & all others lecture?
 What resources do I need?
 Am I ready? new role for me? students ready? how to help
 Process skills: group skills, problem solving, stress
 Assessment of students
 Evaluation of the program

Letter from the Dean

Your Director has just returned from a conference on PBL. The Director asks you to convert your course to the PBL format.

● Case 4: Advice to students

Context: teacher training

Target learning objectives:

learning styles
 role of teacher vs student in learning
 definition of learning
 are test results consistent with learning
 can predict how well students will do?
 how to communicate advice so that it will be accepted
 student preparation prior to course
 remedial strategies
 student development
 grades & rewards

- Case 5 They just don't pull their weight!

Context: third year, week 6, second cycle of the PBL process;

Target learning objectives

Assertiveness
 Dealing with conflict
 Individual accountability in groups
 Teacher anticipating problems and setting up rules for coping ahead of time
 How the teacher can hold individuals accountable to each other
 Contracting
 "Norms" meetings to establish acceptable conduct
 Learning styles
 Effectiveness of prep. workshops

Advice to students: (from Dale Roy, McMaster, with permission)

You are teaching a large enrollment first year course for the second time in a row. Last year it was a matter of getting the bugs worked out but this year you are determined to make the course more effective.

One thing that you found peculiar last year was that you were not really able to say who would do well in the course. Some students that you thought were doing well, had a tough time by the end of the year; the final work of several others was a pleasant surprise. It seems that different students learned quite different things and in quite different ways.

The first month of term is over. you have decided to set aside your lecture for next week and to talk instead to your students about learning.

They just don't pull their weight!

You are using PBL in a third year course. This is the first time the students have experienced this approach in an otherwise conventional curriculum. You assigned students to groups of five or six and tried to ensure that you had a mix of abilities. Indeed, the grade average for all eight groups that you set up was about 76%. Before introducing PBL you ran two hour workshops on "group skills", "being assertive", "how to teach in the teach meetings" and "managing conflict". For the first case problem all of the groups seem to be working OK and the individual reports about the group work didn't show any anomalies. We have just had the second teach meeting. Michelle knocks on your door. After talking briefly about the weather Michelle complains "The other members in my group don't pull their weight especially in the teach meeting! In the goals meeting each contracts with the group that they will "teach" a topic. Then when we have the teach meeting the others don't come prepared. They have no notes to hand out. They don't teach me anything. They tell me that I do a good job of teaching them. But they just don't pull their weight! I want to leave this group and join Andre's group. Andre says it's OK."

- Case 6 Paul's decision

Context: Lifelong learning course to first year students at City University of Hong Kong

Target Objectives:

Setting priorities; Managing time

Budgeting time

Clearer understanding of the expectations in university for time to study

Long and short term planning

Procrastination; Learning to say No!

- Case 7 Mary's group

Context: Lifelong learning course to first year students at City University of Hong Kong

Target Objectives:

Responsible attitude

Communication among group members

Group work/ meeting skills

Discussion skills

Interpersonal relationships

- Case 8: Bitter Cherries

Context: Clinical clerkship; hybrid program

Target objectives:

Biochemical: electron transport system and oxidation redox reactions.

Enzyme binding

Fever and temperature regulation

Consciousness and different states of alertness, dizziness

Pharmacodynamic and drug metabolism

Interviewing patients to clarify symptoms

Delivery of emergency health care in remote areas.

This is handled in two scenarios with 3 h of student research-prep work between Goals and teach.

- Case 9: Tony LoPresti

Paul's decision (Ed Ko, City University of Hong Kong)

Paul has been persuaded by his friends to run for a position on the Departmental Society. He really would like to, but he is afraid that doing so might take time away from his other activities. He is already on the university swimming team and has to work five hours a week in order to earn some money to pay back his credit card loans. With six courses that he is taking this semester, he feels that he is constantly behind in his work.

Mary's group (Ed Ko, City University of Hong Kong)

Mary has been frustrated over the progress of her group on their project. It has always been difficult to schedule meetings. In the first meeting, two of the five group members arrived late. In the second meeting, one member did not show up at all. Even though each meeting lasted several hours, they could never agree on what needed to be done and who should do it. Now they are faced with a deadline for a progress report. Mary is charged with the responsibility of editing each member's contribution into a single report but she can't even locate one of the group members let alone get their work.

Bitter cherries (Luis Branda and Barbara Ferrier, Biochemistry, McMaster University)

It's cottage closing time. The last evening of their weekend at their cottage in the outskirts of the small community of Bancroft, Ontario, the family is relaxing. They remember that early in the season they collected choke cherries and put them in a bottle with vodka with the intention of making sort of cherry brandy. The bottle is brought to the table; the vodka has now a strong red color and smells like Amaretto. Two members of the family drink some of it and find it very palatable. After the short time they feel hot and dizzy; they say they don't feel well and want to be taken to the local hospital. Their breath has the odour of bitter almonds.

Situation II

They are rushed to the emergency clinic in the town hospital where they are given amyl nitrite to inhale and an intravenous injection of 3% sodium nitrite, followed by 25% sodium thiosulfate. Oxygen is administered.

Context: Level III, Adult oncology program, tutored group; Hybrid program

Target Objectives

Hodgkin's diseases,
 Peripheral stem cell transplant
 Hodgkin's versus non-Hodgkin's lymphoma, staging, investigations; diagnosis of Hodgkin's disease; short term and long term complications therapy, infertility
 Cancer therapies
 Young adulthood, sexuality, role change
 Chronic illness
 Crisis and coping
 Uncertainty and anxiety
 Family assessment
 Survivorship issues
 Advocacy issues related to clinical trials, patient decision making, quality of care issues such as delay in diagnosis
 Ethics
 Epidemiology: etiology, incidence, prevalence, prognosis and treatment

This case will be handled over four weeks as essentially three sequential aspects of the case. Students are expected to spend 3 to 5 h each week on this case. Concurrently they have other courses.

Tony LoPresti (Barb Love, Oncology, McMaster with permission)

Situation I

Tony LoPresti is a 22 year old man with a history of newly diagnosed Hodgkin's Disease. He is being seen in the outpatient Oncology clinic today, Dec 15, for further staging of his disease and treatment. He has had a six month history of fever, night sweats and weight loss of 5 kg. He has back pain that is made worse with alcohol consumption. He was initially diagnosed to have chronic prostatitis and was treated with high dose septa in October and November. However, his symptoms did not resolve. Two weeks ago he found a lump in his left groin; lymph node excision and biopsy last week revealed a diagnosis of Hodgkin's disease. His mother has come with him to this appointment. You are the primary care nurse assigned to care for Tony throughout the course of his treatment.

Situation II:

Mr. LoPresti was admitted to hospital yesterday because of altered mental status. Over the past week he has been jittery and last night had one episode of paranoia. He has been admitted for further assessment and observation.
 As this patient's primary care nurse from the clinic, how can you participate in his care during this period of hospitalization?

Situation III

Tony is being seen in the clinic today for recurrence of Hodgkin's approximately 6 months following the completion of 8 cycles of MOPP/ABV chemotherapy. He is being considered for a peripheral stem cell transplant.

As his primary care nurse, how will you assist Tony and his family in preparing for this intensive therapy?

Situation IV

Tony is now 1 month following a peripheral stem cell transplant and consolidation radiotherapy for relapsed Hodgkin's Disease. Physically he is recovering fairly well and appears to be in remission. He will require monthly follow up in the clinic for the next 3 months and then will be seen every 3 months for the next 2 years.

As his primary care nurse in the clinic, what needs and issues may arise during Tony's process of recovery and long term follow up?

● Case 10: Process safety

Context: Chemical process analysis. For the past three weeks we have been analysing the process to make

maleic anhydride from butane. The students have the detailed Process & Information Flow Diagram.

Target learning objectives:

Given the name of a chemical, you will be able to identify whether the chemical is on the HON list, the HON Section F list.

Given various sources and data for the hazardous nature of chemicals, you will be able to define the terms and interpret the degree of hazard and the implications.

Given a process, you will be able to use HAZOP (or equivalent procedures) to identify the conditions for unsafe operation and recommend corrective actions.

Ideal but not critical learning objectives:

You will be able to describe the Natural Step approach and apply it to this process.

- Case 11: Heat exchanger

Context: Engineering course in heat transfer

Target objectives:

Size a double pipe heat exchanger.

Upcoming visit from Occupational Health & Safety

You are the process engineer for the maleic anhydride process. Recently, a process in the US, similar to ours exploded. Fortunately no one was injured but the ensuing fire caused ½ million dollars US damage. Furthermore, new environment legislation is being proposed that really clamps down on emissions and water discharge. We also are having a visit, in four months, from the occupational health and safety branch of the government. Your supervisor requests that you systematically look over your process.

Will the Heat exchanger work?

300,000 lb/h of crude oil, (heat capacity = 0.475 BTU/lb F; viscosity 2.9 mPa.s; thermal conductivity = 0.0789 BTU/ft.h.F; density = 51.5 lb/ft³) are to be heated from 70 to 136 F by heat exchange with the bottom product from a distillation column. The product (heat capacity = 0.525 BTU/lb F; viscosity 5.2 mPa.s; thermal conductivity = 0.069 BTU/ft.h.F; density = 54.1 lb/ft³) at 257,000 lb/h is to be cooled from 295 to 225 F. Available is a tubular exchanger with an inside shell diameter of 23 1/4 in having one pass on the shell side and two passes on the tube side. It has 324 tubes 3/4 in OD of 14 BWG and 12 ft long arranged on a 1 in square pitch and supported by baffles with a 25% cut spaced at 9 in intervals. Will this exchanger do the job?

Table 5-1: Case 10 revisited:

Case 10		Criteria
Problem	<p><i>Upcoming visit from Occupational Health & Safety</i></p> <p>You are the process engineer for the maleic anhydride process. Recently, a process in the US, similar to ours exploded. Fortunately no one was injured but the ensuing fire caused ½ million dollars US damage. Furthermore, new environment legislation is being proposed that really clamps down on emissions and water discharge. We also are having a visit, in four months, from the occupational health and safety branch of the government. Your supervisor requests that you systematically look over your process.</p> <p>As you are thinking about this assignment, Kim walks by and suggests that the HON list would be helpful; Kim suggests that the HAZOP approach is a good systematic way to solve the problem.</p> <p>“Is sustainability something I should also consider?” Kim thought for a moment and then suggested that this was not a direct concern for this problem but the visitors would be impressed if we had at least thought about sustainability.</p>	<p>3. Multidisciplinary</p> <p>6. Openness</p> <p>7. Motivational</p> <p>8. Authentic professional practice</p> <p>10. Only raw data are given that are typical of professional practice</p>
Prior knowledge	<p><i>Context:</i> Chemical process analysis. For the past three weeks we have been analysing the process to make maleic anhydride from butane. The students have the detailed Process & Information Flow Diagram.</p>	<p>2. Builds on past knowledge</p>
New knowledge	<p>Use of systems thinking, integration of health and safety issues into concept of a process</p>	<p>6. Openness and integration</p>
Cues	<p>chemical process, exploded, emissions, water discharge, environmental legislation, government, health and safety, HON, systematically identify potential hazards for a process, HAZOP, sustainability</p>	<p>4. Cues given</p>
Learning issues	<p>Given the name of a chemical, you will be able to identify whether the chemical is on the HON list, the HON Section F list.</p> <p>Given various sources and data for the hazardous nature of chemicals, you will be able to define the terms and interpret the degree of hazard and the implications.</p> <p>Given a process, you will be able to use HAZOP (or equivalent procedures) to identify the conditions for unsafe operation.</p> <p>Given a process and identified conditions that are unsafe, you will be able to recommend corrective actions.</p> <p>For enrichment about sustainability: Given a process you will be able to apply a systematic approach, such as the Natural Step approach, to identify areas for potential action</p>	<p>1. Based on learning objectives</p> <p>1. Achievable with four major learning objectives</p> <p>1. Achievable with each objective requiring about 3 hours of research plus 2 hours of planning how to teach.</p> <p>6. Requires challenging thinking</p>

- Case 12: Investments

Context: Engineering economics

Target objectives:

Concepts and calculations for interest and depreciation
 How to read a financial statement
 Investment options versus risk
 Personal finance and budgeting

Investment opportunity

You have been hired with an annual salary of \$54,000. Your company is listed on the stock exchange and has publically traded shares. They offer a share purchase plan to all employees. For every share of common stock you purchase, they will purchase one in your name. How do you respond to the company's offer. A copy of the annual report and its performance on the stock exchange are given.

Case 13: Intro to Chem Eng (based on material of Wayne Seames, Univ of North Dakota)

Context: Introduction to chem eng

Target objectives:

Concept of unit operation
 Difference between a chemical and physical process
 Three common systems of units
 Concepts of dimensions and how to use them

Ollie and Marta's first day

"Welcome to our company," said Tex Mexan, Ollie and Marta's new boss. "We've been shorthanded and we want you to start your experience with our company working on a small process we need to develop for our Marisland plant. They want to convert their existing Polytoxic plant to accommodate the polygreeneric process. It was developed by a former employee. However, we have to find a way to make that polymer safer without increasing costs or reliability. Here's the file; get to work!"

The file contained 15 process flow diagrams of the existing plant. It was a series of drawings documenting the equipment, flow rates, temperatures and pressures in all the existing process (all given in common units of measurement, lbs, psi, °F). The file also contained a report documenting the polygreeneric process. It contained page after page of calculations (all in metric units, g, kg/ cm², °C) plus one simple generic sketch - boxes really - of the process.

"How can we make sense of such a huge problem? I just don't see how we can relate these two, disparate documentation sources to each other?" Ollie exclaimed. "Besides, I thought that when you made a polymer you just reacted stuff together and made the polymer. This drawing shows all types of equipment but I only see one piece of equipment called *reactor*. What's going on here? Are they just trying to make it complicated because we are new to the company?"

Marta closed her eyes and tried to think of something she had read about that might relate to this problem. Suddenly she smiled and said to Ollie "Unit Ops".

"Unit OPs? What's that?" Ollie had never heard of this subject before and he couldn't see how this could help them make sense out of the two files and link the two together to make the new process. Did some of the equipment in the new process replace some in the old process or did you just link the two sets of equipment, or files, together?

Case 14. For a section of a process, what kinds of hazards to life (because of health, fire and explosivity) might occur? For the present focus on identifying quantitatively the type of hazard and identifying conditions that might cause the hazard to exist.

Resources

MPS Unit 22 Broadening Perspectives

example, p. 215 MEK from D.G. Austin and G.V. Jeffreys (1979) "The Manufacture of methyl Ethyl Ketone from 2-Butanol," Institution of Chemical Engineers, London. p. 167-178 for the reactor section only.

Handout re TLV

W.F. Kenney (1993) "Process Risk Management Systems," VCH Publishers, New York.

p. 4-18, *** reading for introduction.
Hazard Identification p. 47-59, 64-74; **
Hazard necessary? p 75-113. ***
Risk Identification. p 115-150 ****
Risk Assessment, p. 151-165; 175-184; ***

T.A. Kletz (1992) "HAZOP and HAZAN: Notes on the Identification and Assessment of Hazards," Institution of Chemical Engineers, UK, Rugby, Warwickshire, UK Defines HAZOP, p. 7 as the process of considering none, more of, less of, part of, more than and other than. ** [In MPS 22 we consider "start up," "shut down," "switch over," "power failure," "barrier failure." plus No, Add, +/-, Part, unexpected, p. 2211]
example, p. 14, ***
fault trees, p 49 **

T.A. Kletz (1985) "What Went Wrong?" Gulf Publishing Co., Houston TX. Examples, not much theory. *

G.L. Wells and L.M. Rose (1986) "The Art of Chemical Process design," Elsevier, Amsterdam

- Chapter 13 Safety and Loss Prevention. Very similar to Wells (1987).
- options: p. 464-467 ***
- HAZOP. p. 469-475 **
- HAZAN fault tree, 475-483 **
- example, p. 496-505. ***

G.L. Wells (1987) "Safety in Process and Plant Design," Chapter 9 in "Recent Developments in Chemical Process and Plant Design, Y.A. Liu, H.A. McGee, Jr., and W.R. Epperly, John Wiley and Sons, New York, NY

- very similar to Wells and Rose
- options, p. 333-335. ***
- HAZOP, p. 338-339 **
- HAZAN p. 341 **
- example, p. 348-355 ***

Woods, D.R., transparencies for "lecture notes" **

Air concentrations

TLV-TWAC (TLV-TWA) Threshold Limit Value-time weighted average

Time weighted average concentrations (or levels) of an agent for an 8-hour day with a weekly exposure of 40 h to which, it is believed, *nearly* all workers may be exposed, day after day, without experiencing adverse effects. Note that TLV-TWA states "nearly all workers" - not "all workers." There will be an occasional worker who is hypersusceptible by reason of a peculiar genetic condition or unusual environmental factors and therefore may not be included in these limits even though the limits contain large safety factors.

TLV-STEL (Threshold Limit value- short term exposure limit)

Maximum concentration of an agent in the air to which workers may be exposed from time to time. However, the exposure of a worker to this maximum concentration should be:

- not greater than 15 min.,
- not greater than four times per day
- only after 60 min have elapsed from the time of the last exposure to such a condition.

Case 14 is similar to Case 10 and Case 10 revisited, Table 5-1. The case problem has different wording. Which one do you prefer and why?

Case **14** illustrates how one might provide the students, and the librarians, with a resource list. This addresses Step 9 in the process of implementation.

Additional examples of Problems in the context of managing people are given p 11 ff in the book Wee, Sun, Boon, Ng and San "A PBL Module on Managing People," Prentice Hall, 2003

Roles of students and of teacher in PBL

Table 5-2 suggests the roles of the students and the teachers for the following version of small group, self-directed, self-assessed interdependent PBL using tutorless or autonomous groups. Here one problem is considered each week; there are three meetings: the goals meeting, the teach meeting and the exam or feedback meeting.

TLV-C (Threshold Limit Value-ceiling)

Concentration of an agent that should **not** be exceeded at any time.

Misuse of Criteria

1. Do not use these criteria to "compare toxicity."

SO ₂	TLV-TWA	2 ppm
H ₂ S	TLV-TWA	10 ppm

SO₂ is not 5 times more toxic than H₂S. Each has an entirely different effect on the human system.

2. These data apply to workers. They do not account for populations of all ages and states of health or for periods of exposure > 8 h work day.

Use

Calculate the time-weighted average exposure concentration for any given set of conditions and see how this compares with the standards.

Table 5-2 Roles of students and teachers for PBL

	Activity	Student's role	Activity	Teacher's role
1			Preparation	Prepare learning objectives
2				Create problems
3				Create list of resources & tell library
4				Locate room with flat floor, movable tables and chairs
5		Try out problems, use cues to create objectives		Test out problems
6				Revise problems
7				Assign students to group; prepare list to give to students
8				Create rules about attendance, failure to hand in reports. The letter
9				Make list of chairperson responsibilities; give to students
10				Prepare startup workshops*
11		Students participate in workshop	Prepare the students	Run workshop: What is PBL?*
12		Students participate in workshop*		Workshop: are you ready for PBL?*
13		Student complete Perry Inventory		Teacher score as needed (KAI). Jungian and LASQ are self scoring*
14		Students complete Jungian typology, LASQ and KAI*		Teacher prepare process skill training*
15		Students participate in workshop*		
16		Student write up journal about the workshop*		
17				Teacher mark journal: 50% for skill in self assessment and 50% for target skill*
18		Students participate in workshop*		Workshop: self assessment MPS 3*
19		Student write up journal about the workshop*		
20				Teacher mark journal: 50% for skill in self assessment and 50% for target skill*
21		Students participate in workshop*		Workshop: Group skills. MPS 28*
22		Student write up journal about the workshop*		
23				Teacher mark journal: 50% for skill in self assessment and 50% for target skill*

	Activity	Student's role	Activity	Teacher's role
24		Students participate in workshop*		Workshop: strategy. MPS 4*
25		Student write up journal about the workshop*.		
26				Teacher mark journal: 50% for skill in self assessment and 50% for target skill*
27		Students participate in workshop		Workshop: Goals and Teach meeting*
28		Students get in their assigned groups. They will stay with the same group for all semester (12 weeks). Students may have a starting "norms" meeting to introduce themselves and to address the guidelines of how they want their group to work		Teacher provides list of 17 possible things to think about for an effective group (p B-35, Resources book)
29		Chairperson prepares and distributes agenda		
30	Goal Meet	Students read over the problem, identify what they need to learn, write as learning objectives	Teacher monitors	Teacher checks on the list of learning objectives from each group
31				Teacher signs form 1-13
32		After the students receive the validation from the teacher, they formally write up their learning objectives, they contract with each other. Set up rules of behaviour, share learning style information with other group members		Teacher monitors to see that all group members are present; makes notes if some members are missing
33		Individuals complete the feedback to chairperson form (if chairperson skills are part of your program) and gives form to chair		
34		Group completes assessment form about group process; 1-3; will use as evidence about group skill development		
35		Individuals learn about their topic, prepare "teach notes"; think about the learning styles of all the members		Teacher is a consultant to any student <i>who asks</i>
36		Chairperson prepares and distributes agenda		
37	Teach Meet	Each student teaches the others.	Monitor	Teacher monitors to see that all people are present; if some were missing at the first meeting, asks the group if they want the teacher to send the letter ; sends letter to delinquent student if authorized. Monitors to see that all members are present for the Teach Meeting
38		Group use the information to solve the problem. They check that the learning objectives given in step 32 were achieved.		
39		Group elaborates about how the new knowledge could be used in other contexts; reflects on what they learned		

	Activity	Student's role	Activity	Teacher's role
40		Individuals complete the feedback form p 1-12 on quality of the teach for each member (including self) and give forms to everyone		
41		Individuals complete the feedback to chairperson form (if chairperson skills are part of your program) and gives form to chair		
42		Group completes assessment form about group process; 1-3; will use as evidence about group skill development		
43		Students study on their own or as a group any topics that they don't understand.		
44		Chairperson prepares and distributes agenda		
45		Each student prepares a "good" 10 min question (and answers). The question should be in the topic that the student did not teach in activity 34 and 37.		
46	Exam Meet	Students critique the various questions and select the "best" using the criteria of the learning goals approved by the teacher in activity		Teacher monitors to see that all people are present; if some were missing at the first two meetings, asks the group if they want the teacher to send the letter ; sends letter to delinquent student if authorized. Monitors to see that all members are present for the Exam Meeting. Keeps track of time!
47		Each team receives a question from another group. The team writes out a group answer.		Teacher collects one question from each group and delivers it to another group such that the source of the question is not known by the students. Keeps track of time!
48		Markers are sent to each group to mark the group answer		Teacher reveals the source of the question and asks that each group send a "marker"
49		Group puts together a copy of its 1) best question and 2) answer and 3) the group's answer to the question they created and had marked in step 48. Each group submits this to teacher.		Teacher marks the three results and records marks for all group members
50		Individuals complete the feedback to chairperson form (if chairperson skills are part of your program) and gives form to chair		
51		Group completes assessment form about group process; 1-3; will use as evidence about group skill development		

	Activity	Student's role	Activity	Teacher's role
52		Students study on their own or as a group any topics that they don't understand.		
53		Individual students prepare report about PBL based on evidence (31, 32, 35, 38, 39, 40, 43, 45, 52) and his/her analysis of the evidence and submit to teacher		Teacher mark journal: 50% for skill in self assessment and 50% for target skill of PBL or lifelong learning
54		Individual students prepare report about chairperson skill based on evidence (28 and 33 or 36 and 41 or 44 and 50) and submit to teacher		Teacher mark journal: 50% for skill in self assessment and 50% for target skill of chairperson
55		Individual students prepare report about group skills based on evidence (34, 42, 51) and submit to teacher		Teacher mark journal: 50% for skill in self assessment and 50% for target skill of working in groups .
56		Cycle repeats starting at 29		

* These activities only have to be done **once**.

The **letter** is given on page D-24 of the Resources book and can be downloaded from <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL and then download Chapter D from *Problem based Learning: Resources to gain the most from PBL*.

For activity 28, the *norms* meeting, the 17 issues are, 1. need for chairperson, 2. terminology for problem solving, 3. type of brainstorming approach, 4. decision making procedure, 5. role of chairperson in decision making, 6. resources needed, 7. record and distribute minutes of meeting?, 8. roles, 9. meeting agenda, 10. Sandler's rules, 11. how to handle conflict, 12. how to combat group think, 13. willingness to share personal information about "styles" with all group members, 14. level of intervention desired, 15. how to handle emergencies, 16. how to handle emotional issues brought to the group, and 17. how to ask a member to leave the group.

6. How to develop processing skills for learners?

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Case 4: How much is enough?

“We have taken six hours of precious class time to run workshops on Problem Solving Strategies and on Group skills” exclaimed Jon. “We can’t take more time to train them in these “soft skills”. Besides, what additional skills do they need? These students are graduating from a Polytechnic! They’ve got to have technical knowledge. Let’s get on with it. Let’s use the first case problem on Monday.”

Activity: In small group of 5 or 6, with chair _____;
reporter _____, brainstorm the issues this case raises. Identify what you know already.
Identify what you need to learn.

Prioritize the issues: criterion: what do you want to gain from this workshop in the context of the issues raised.

Feedback about the group work. Form **2802**

Task: Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. The accuracy in the group's answer matched the time available. Group avoided contributing excessive information.

None of these behaviours	Few of these behaviours but major omissions	Most features demonstrated	All of these behaviours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	6	7	

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

None of these behaviours	Few of these behaviours but major omissions	Most features demonstrated	All of these behaviours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	6	7	

Individual Contribution to Task and Morale

Group Strengths

Group Areas to work on

Feedback from the Goals Meeting

Case 4:

Issues

Number identified: 1 2 3 4 5 6 7 >7

Agreement with tutor <50% 50% 60% 70% 80% 90% 100%

Knowledge/skills to be learned

Consensus among group little some a lot complete

Agreement with tutor's list little some a lot complete

Learning objectives

Quality poor fair OK good excellent

Learning

Quality of questions asked during the teach session none some astute excellent

Willingness to continue to contribute <50% 50% 60% 70% 80% 90% 100%

Your Attitude

Perry shift 2 3 3.5 4 4.5 5

Reflections:

1. The need

The processing skills are needed for two reasons.

1. The usual set of desired *outcomes for programs* include expertise in the subject discipline and skills in oral and written communication, problem solving, team work, managing change and lifelong learning.
2. The usual set of skills needed by students so that *they perform well* in **PBL** are skills in oral and written communication, problem solving, team work, managing change, self assessment, elaborating and learning and teaching others.

A common core of skills include:

- problem solving (seeing strategies, monitoring, creativity, defining problems, creating the look back)
- managing change or making the transition to a new learning environment (stress and time management, understanding personal uniqueness and skills)
- group skills (interpersonal skills, group work, managing conflict, developing trust)
- teaching others (learning skills, understanding personal uniqueness, goal setting, learning contracts)
- self assessment.

2. How to develop

The graduates need skill and confidence to that they can use the skill effectively. As Bandura has illustrated, workshops, that give participants a chance to try a skill and get prompt feedback, seem to be the most effective approach.

Step 1. Define the skill base on research, not intuition. Publish target behaviours of successful persons performing the skill. Some examples are published:
<http://www.chemeng.mcmaster.ca/innov1.htm> and click on MPS and look for “target skills”

Step 2. Create learning objectives for the skill. Some examples are published:
<http://www.chemeng.mcmaster.ca/innov1.htm> and click on MPS and look for “objectives”

Step 3. Design the worksheets (feedback forms and forms of evidence that participants will use to show performance accomplishments)

Step 4. Work out the “timing sheets” for how you will manage the workshops.
 An overall template for the workshops

- Define
- Rationalize
- Pretest
- Objectives
- Route ahead

Activity with feedback
 Reflections
 Activity with feedback
 Description of target behaviours
 Activity with feedback
 Reflections
 Activity with feedback
 Continue until the participants feel they can achieve the objectives
 Objectives
 Post Test
 Discovery

In Large Class-- Workshop #2 -- we introduced the workshops MPS 4 Problem Solving strategies and MPS 28 Group skills.

In this workshop, we introduce workshops:

Managing Change MPS 49

Self-directed Learning/teaching MPS 36

Enrichment:

1. Please help me understand how best to help you
2. MRIQ
3. MPS 49 and 36 (goals, targets, workshop, timing)

References:

<http://www.chemeng.mcmaster.ca/Innov1.htm> and download MPS materials

Woods “Problem-based Learning: resources to gain the most from PBL” Chapter D for objectives. downloadable from <http://www.chemeng.mcmaster.ca/innov1.htm> and PBL; and Chapters B and C.

Woods “Problem-based Learning: helping your students gain the most from PBL” Chapter 3 downloadable from <http://www.chemeng.mcmaster.ca/innov1.htm> and PBL for an overview of the process skills.

MPS-4 Strategy

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CANADA

Jan. 200, Apr 2002

A Strategy is an organized approach used in solving a problem. Such an organized approach identifies steps or stages for different parts of the process. For example, there is usually a stage called "Read the problem". Another stage might be called "Check the answer I obtained." The author George Polya describes a four-step strategy that includes the steps "Define, Plan, Do it, and Look Back". A strategy is important because:

- we all usually use one,
- a strategy helps us to be organized and systematic,
- having a strategy helps to calm us down if we become anxious when we are given a very difficult problem to solve,
- having a strategy helps us to "monitor" our mental processes.

In this UNIT the goal is to help you to discover names for the stages you use, to help you identify the thinking and attitudinal skills needed during different stages, to help you see how many minutes you spend in the different stages and to help you to monitor your thinking. To help you get this skill, two of you will work together: one will play the role of a "TALKER and marker mover" ; the other plays the role of the "LISTENER and recorder".

McMaster MPS 4: Strategy Objectives © copyright, Donald R. Woods, 1998

MPS 4: Strategy: is the organized and systematic sequence of stages applied when problems are solved. Each stage is characterized by its own set of attitudes and thinking skills. Example: the four-step problem solving strategy published by Polya: Define, Plan, Do it, Look back.

Skill development:

1. More skill in being able to talk about thought processes.
2. More practice to focus on accuracy (instead of on time).
3. More practice on being active and writing things down.
4. Recognizing that others solve problems differently than they do.
5. Acquire more skill at listening.
6. Acquire more skill in self assessment.
7. Acquire more skill in giving and receiving feedback.
8. Through self awareness, to improve self confidence.
9. Further emphasis that assessment is based on **evidence**.
10. Continuing to develop an environment of trust where risking is OK.
11. Beginning to recognize patterns in the problem solving process.
12. To realize that a “strategy” is not applied **linearly** and sequentially; that it is used flexibly.
13. To recognize the difference between *problems* and *exercises*.
14. Understand the relationship between subject knowledge, past solutions to problems and problem solving.
15. To acknowledge the importance of **defining** problems and to recognize this as a three-step process.
16. To acknowledge the importance of **reading** the problem statement.
17. To realize that *problem solving* is not “doing some calculations.” Conversely, to correct the misconception that if you are not “doing some calculations” you are not solving problems.
18. To acquire skill is explicitly monitoring the process.

Pretest: It is very difficult to realize how much we change in our thinking and research skills from the workshop activities that you are going to do. To help you develop your confidence and be proud of the progress you make, before you do the workshop activities, please mark your skill now .

Awareness: how aware are you of what you do when you use a strategy? Rate with an “x”

0	1	2	3	4	5	6	7	8	9	10
Unaware				Aware of					Very aware	
I just				Some					I can describe	
do it									The details of	
									how I do it	

Skill: how skilled are you in doing this activity? Rate with an “x”

0	1	2	3	4	5	6	7	8	9	10
Poor		Fair		Good			Very good			Excellent

Comments:

MPS 4 Strategy

- 1.1 given a term listed under "concepts introduced", you should be able to give a word definition, list pertinent characteristics and cite an example.
- 2.1 given the name "McMaster 6-step strategy," you should be able to describe each and list the cognitive and attitudinal dimensions associated with each step.
- 2.2 you will be able to describe the concept of "nested strategy" and given a problem, identify the number of times the 6-step strategy might be used to solve the problem.
- 2.3 given a problem in a TAPPS Whimbey-pair context, you should be able to verbalize the process and place a marker to identify the step (in the McMaster 6-step strategy) upon which you are working. The listener should agree with your assessment 80% of the time. You should need prompting no more than 3 times in a 7 minute period.
- 2.4 given a problem in a TAPPS Whimbey-pair context, as a listener you will encourage verbalization, an emphasis on accuracy, active thinking and problem solver to move the marker correctly on the strategy board. Your interventions will be judged by the problem solver to be *helpful*, and not judged to be *disruptive*.
- 2.5 given the TAPPS Whimbey-pair context, you should exhibit 4 verbal management statements during a 7 minute period of problem solving.
- 2.6 you will be able to list the misconceptions people hold about the use of *strategies*.
- 4.1 given a problem in a TAPPS Whimbey-pair context, as a listener you will be able to identify *monitoring* statements said by the problem solver. Your assessment will agree with the tutor's assessment 80% of the time.
- 5.1 given your goal is to improve your application of a strategy, you will be able to identify subgoals, write these in observable terms, create consistent measurable criteria, gather evidence to substantiate claims and write a reflective journal to summarize your claims.
- 6.1 given evidence gathered from a strategy workshop, you will be able to assess the degree to which goals of the workshop have been achieved. Your assessment will agree 90% with the tutor's assessment.

Concepts introduced

McMaster 6-step strategy, criteria for selecting a strategy, attitudinal and cognitive dimensions of each step in the strategy, Schoenfeld's monitoring/management, nested strategy, role of TAPPS problem solver, role of TAPPS listener, three stages of defining a problem, importance of creating the *internal representation*, importance of *reading* the problem statement.

Playing the role of the TALKER- MOVER of the marker.

Your role is to talk aloud when you work on the problem and you are to move a marker on the "strategy board" so that you show which stage your thinking is in.

This is difficult to do. Be patient with yourself.

You may not completely understand the meanings of the stages yet. You may use different stages than the ones on the Strategy board. Please, do your best.

The listener will not move the marker for you. The listener will not tell you what stage you are in. The listener might ask you "are you still in the "Explore" stage?"

Remember to keep talking, to be active, to use pencil and paper, and to check and check again. Before you start, go over the meanings of the 6 different stages in the McMaster-6-Step strategy with the LISTENER. Agree on the meanings of the words.

1. Sit side by side; have paper and pencils available, have the Strategy board and the marker.
2. The talker moves the marker to the READ part of the Strategy Board and starts by reading the problem statement aloud.
3. Then move the marker to whatever stage you are going to work on next and start to solve the problem *on your own*. Keep talking aloud. *You* are solving the problem. Your partner is only listening to you. He or she is not solving the problem with you or for you.
4. Talking and thinking and moving the marker at the same time are not easy. You might forget to move the marker. That is OK. Do the best you can. You are playing the role and trying out something from Canada.
5. Go back and repeat any stage of the strategy you wish.

Playing the role of the LISTENER-RECORDER

You have an important and difficult role to play. You are to help the Talker see what he or she is doing as they talk about the travels of their mind as they solve problems and you are to record the amount of time the Talker spends in each of the stages on the Strategy Board. Do not correct them; do not argue with them about which stage the TALKER is working on. Do not move the marker for them. You may have to ask "Are you still in the >>>>> stage? Before you start, go over the meanings of the 6 different stages in the McMaster-6-Step strategy with the TALKER. Agree on the meanings of the words. You might want to review the instructions for the LISTENER from MPS Unit 1 on AWARENESS.

Activity: In pairs, one be a talker, the other be a listener. The talker plays the role for _____ and "solves" problems during all the allotted time. Do not change roles.

Later you will switch roles.
The Strategy Board is given on Page
The listener record sheet is given on Page
+++++

Write evidence by reflection on Table 4-1 p. 4-5; Get evidence about the listening on Table 4-2, p. 4-6.

Table 4-1 : A Place for you to Record your ideas about the Strategy Activity: **Reflections**

Being the TALKER-MOVER of the marker:

Being the LISTENER/RECORDER

About the process

Table 4-2 : **Evidence for listening:** Feedback to listener: listener you will .encourage verbalization, an emphasis on accuracy, active thinking and problem solver to move the marker correctly on the strategy board. Your interventions will be judged by the problem solver to be *helpful*, and not judged to be *disruptive*.

Activity 1: talker _____ Case _____ listener _____

encourage verbalization:	not needed	interruptive	OK	really helped
encourage emphasis on accuracy:	not needed	interruptive	OK	really helped
encourage active thinking	not needed	interruptive	OK	really helped
interventions:	not needed	interruptive	OK	really helped

Comments:

signed _____ talker

+++++

Activity 2: talker _____ Case _____ listener _____

encourage verbalization:	not needed	interruptive	OK	really helped
encourage emphasis on accuracy:	not needed	interruptive	OK	really helped
encourage active thinking	not needed	interruptive	OK	really helped
interventions:	not needed	interruptive	OK	really helped

Comments:

signed _____ talker

Schoenfeld and Voss have shown that we should "monitor" how well the thinking activities are helping us toward the goal of solving the problem successfully. The monitoring process includes:

- *Assessing the benefit to be gained from a thinking activity or a calculation before we do it. For example, "If I calculate, what will that tell me?" "If I ask this question, what will that tell me?"*

- *Assessing whether a task is completed. This is a natural question that you ask yourself when you are ready to move the marker on the Strategy board. For example, "Am I finished with this?" "Now where do I go?"*

- *Assessing what you have learned if a hypothesis is shown to be wrong or if you calculate a "strange answer." For example, "OK, What did I learn from that?"*

- *Checking for completeness....*
 - *do you list the options? then put them in order of importance? and then check them off when you do them?*
 - *do you give up on a calculation without checking on what you learned from the work?*
- *Monitoring.... where you are and where you are going... at least once per minute.*

Schoenfeld's evidence is in Table 4-3; Other target evidence is shown in Table 4-4

+++++

Activity:

In the second time that you play the role of the TALKER-MOVER you will now try to say aloud the assessing and checking for completeness and monitoring described above.

In the second time you play the role of the LISTENER-RECORDER you will also put a little black arrow ▼ on the chart whenever the talker assesses, checks for completeness and monitors.

Ref: Schoenfeld, A.H.(1985) "Mathematical Problem Solving" Academic Press, Orlando, Fla.

+++++

Table 4-3 : Schoenfeld's research :

Unsuccessful	Successful
Don't assess potential	Assess the potential: what will I learn if I do this calculation? Will this help me? How does this move toward a solution?
If fail, abandon	If fail ask "What did I learn?"
Make impetuous jumps with no apparent reason	Actions characterized by continual assessment & curtailment
Within the first few minutes, become fixed on one idea	Qualitatively explores situation to fully understand; Keeps options open
No monitoring	Explicitly monitors about 1 / minute; and uses transitions between strategy stages as key monitoring/decision points. "Am I finished with this stage?" "Where now?"

MPS 4 Strategy © copyright, Donald R. Woods, 1998

Table 4-4 Evidence-based targets for problem solving

Evidence-based targets	Progress toward internalizing these targets				
	20%	40%	60%	80%	100%
● Spend time reading the problem statement. (Up to three times longer than unsuccessful problem solvers) (11, 24)					
● Define the problem well; do not solve the wrong problem. Be willing to spend up to half the available time defining the problem . Most mistakes made by unsuccessful problem solvers are made in the define stages (1, 3, 4, 11, 12, 19, 24)					
● You solve your mental image of the problem; such a mental image is called the <i>internal representation of the problem</i> .					
● Differentiate between <i>exercise solving</i> and <i>problem solving</i> .					
● Unsuccessful problem solvers tend to search for an equation that <i>uses up</i> all of the given variables. (1, 4, 11, 12, 14, 24) whereas successful problem solvers focus on an organized strategy that focuses on defining the real problem.					
● Unsuccessful problem solvers tend to memorize and try to recall equations and solutions that match the situation instead of defining the real problem and identifying key fundamentals. (11, 6)					
● Defining the problem is a three-stage activity (19, 24).					
● Unsuccessful problem solvers tend to take a trial and error approach; successful problem solvers use a systematic strategy (6). Use a strategy to help you to be systematic and organized					
● A strategy consists of a series of about 6 stages. Each stage uses different thinking and feelings. This strategy is not used serially (following rigidly one step after another). Rather it is used flexibly; applied many times while solving a single problem with frequent recycling from one stage to another. (24)					
● Problem solving skill interacts with subject knowledge (needed to solve the problem) and with the sample solutions (from past solved problems).					
● Successful problem solvers monitor their thought processes about once per minute while solving problems. (20, 19)					

References 1 to 24 are from the Novice versus expert research summarized in PS News 55

STRATEGY MPS -4: Case 1: Judge Dee and the Case of the Old Fashioned Pen.

Rodney Stites, professor of French at State University, lay dead across his desk. It looked like suicide.

"I hear the gun shot about an hour ago," said Carl, the manservant. "I came into the room quickly and then called you then." Judge Dee, the detective, walked to the desk, that was located in the middle of the professor's library. "Carl, did you touch anything?" "I only touched the telephone," replied Carl.

Judge Dee examined the body. Death, which occurred within the past hour, was caused by a bullet that was fired into the right temple at extremely close range.

A thirty-two calibre gun lay on the thick carpet on the floor to the right of the professor's head. On the desk was a note. The note was written in ink, with several blobs of ink smudges. The note read: "I do not want to live anymore without Elsie."

"Elsie, the professor's wife, ran off with a young artist last year," remembered Judge Dee.

The judge now looked carefully at the top of the desk. The dead man had the old-fashioned quill pen clutched in his right hand. An open, antique inkwell sat next to the desk phone about 2 cm from the point of the pen. Some ink spots were on the desk top near the end of the pen. On the base of the inkwell was engraved "For Rodney on our Tenth Wedding Anniversary. Love Elsie."

"Call the police," said Judge Dee. "This is murder and not suicide."HOW DID JUDGE DEE KNOW?

STRATEGY MPS-4: Case 2: The Case of the Phony Policeman.

"I am the lawyer for Mr Franklin D. Van Clausand, II, who has been falsely accused for murder and robbery," said Goodwin as he sat down in the chair in Judge Dee's office. "Franklin has been working for a year in one of his father's banks. Last Tuesday, before the bank opened for business, a man dressed like a policeman came to the front door and demanded to be let into the bank. He looked like a motorcycle policeman: he wore a black leather policeman jacket, boots, dark sun glasses and a white, policeman's motorcycle helmet. Of course he wore a policeman's badge and he showed special identity papers. Franklin was closing the door on the money vault, when the fake policeman drew his gun and put the muzzle of it against the right hand side of Franklin's neck. He forced Franklin to fill a bag full of money. When the fake policeman was leaving the bank, the bank guard drew his gun. Two shots were fired. The guard fell; dead.

" Franklin provided the only description of the killer. The fake policeman was about 30 years old, 1.8 m tall, with fair complexion, blue eyes and a scar on his upper lip that was shape like a crescent.

"That afternoon, the police arrested Edgar Burgess for driving too fast. He matched the description and \$300 000 was found in his car. Burgess became very angry when he found out that Franklin had given so accurate a description of him. Burgess said that Franklin was in on the robbery with him and had told him when and how to come to the bank. What nonsense! Franklin swears that the first time he ever saw Burgess was in the bank."

Judge Dee said "Is it really nonsense?" WHY DID HE SAY THAT?

STRATEGY MPS-4 Case 3: The Case of the Phony Crash

Judge Dee was outdoors camping and had just turned over in his sleeping bag when he saw a big car come down the short dirt road, which came off the main highway, and disappeared over the cliff.

Running after the car was a tall man. He stopped at the edge of the cliff, then he lay down on the ground and moaned and cried, "Help! Help! My back hurts so much!."

Four others from the camping group ran over to the man on the ground. Judge Dee went down the cliff to look at the car. It was overturned and totally wrecked. About the only things that were not broken were the four worn out tires, which turned slowly in the air.

Two days later, Judge Dee talked to Mr Abbott, the insurance man who said, "Mr Staines says that while he was driving, he fell asleep at the wheel and woke up just in time to jump out of the car before it went over the cliff. Now he is asking us to pay the full automobile insurance worth the full price of the car, \$12,000. You see, he just bought the car new five days ago. But the large amount of money that he is asking for is for his hurt back. He says he hurt it so badly when he jumped from the car, that he cannot work any more. He expects us to pay the insurance that is worth \$5000 per month. We think he faked it all.

"You are the only witness, Judge Dee, but the lawyers for Staines say that you could not have seen much because it was night and you had been asleep."

Judge Dee said, "I will not have to testify. Staines planned to wreck his car and do this "imaginary" story."

HOW DID JUDGE DEE KNOW?

STRATEGY MPS-4: Case 4: The Case of the Railway Crash.

On the night of July 15, the engineer of the westbound local train missed a signal and the train crashed head-on with the Rocket, the high speed express train out of Toronto. The result was one of the worst disasters in train history.

Judge Dee said,"I think it is strange that all of the serious injuries were in the first seven cars of both trains...except for Jess Fromm who was killed in ninth car of the local train. I have been asked by Fromm's daughter to investigate."

The police inspector asked the Judge to be seated and then the inspector went to his files. "Fromm was going to a merchant's convention with his business partner, Wendel Smith. According to Smith's testimony, he and Fromm shared compartment C in the last car of the local train. Just seconds before the crash, Fromm got up and walked toward the front of the compartment toward the toilet. When the trains collided, Fromm was standing. He was thrown back and struck his head against the top of the table that was between the two seats. The seats were facing.

"Smith now owns all of the business," said the inspector. "Maybe that was the motive. What about the method? Maybe Smith hit Fromm in the back of the head with the table AFTER the crash. But how are we going to prove it?"

"That is easy to prove," said Judge Dee.

WHY DID THE JUDGE SAY THAT?

the Back.

Judge Dee was out taking his daily walk on a cold November evening when he heard a gun shot. He saw an old man suddenly lean against the front door of a nearby house, fall and lie motionless on the porch. Two other men and the Judge ran toward the old man. He was dead.... shot in the back.

The Judge turned to the two other people and said, "Each of you should have a good alibi. I am sure that one of you shot this man, and then threw away the gun".

Both men, who were wearing gloves and tight overcoats, said that they did not know the old man. Both said that they were out for a walk.

The first man said, "I am Ted Briggs. I noticed the old man locking the front door a split second before I heard the shot. I ran right up to him. But this man," and he turned to the second man, "was right in front of the house and his position seemed to be in a line from where the shot came from."

The second man said "I am Sid Cole. I heard a shot, but did not connect it to the old man. I did not know what had happened until I saw the two of you running toward the house."

The key was still in the front door. Judge Dee turned it, entered the house, and telephoned for the police. Twenty minutes later, Judge Dee explained to Inspector Winters "The dead man's wife is an invalid sick in bed. The old man was going to the drugstore. He always locks the house when he leaves her alone."

"Do you have any ideas?" asked the Inspector.

"Yes," said Judge Dee, "Arrest" WHOM?

STRATEGY MPS-4: Case 6: The Case of the Silver Pen

"The police have been here all morning, darling! It has been terrible!" said the Hollywood movie star, Vivian Hobson. Hobson, a star for many years, was in the middle of the stage production of "Cats" but now looked worn out. Judge Dee, an old friend, studied the bedroom, from which the actress's daughter Shari had been kidnapped the previous night. A rope, made from bedsheets and tied to one of the bed legs, hung out the window to within about 2 m of the ground.

"The kidnapper must have crept into the house during the day, because everything is locked at night," said Vivian. "I was on the upstairs porch around midnight when I saw a man climbing down the rope made from the bedsheets. He had my daughter Shari over his shoulder. She was limp. He must have knocked her unconscious. The bad guy!"

"Has anything been moved in the room?" asked the Judge.

"No, everything is exactly as it was," said Vivian.

The Judge went downstairs, and outside and saw a boy delivering newspapers. "Would you please help me do an experiment?" asked the Judge. "I want you to act out what the kidnapper did."

The boy went up the stairs, pretended to knock someone out, put the imaginary person over his shoulder and then climbed out the window and down the rope safely to the ground. As he went out the window, the bed was dragged several centimetres from its position against the wall, and uncovered a silver pen on the floor. The Judge picked up the pen, looked at it carefully and said, "Vivian, you faked the kidnaping to get publicity for your new play, Cats". WHY DID THE JUDGE SAY THIS?

STRATEGY Board: (from Woods, "Problem-based Learning: how to gain the most from PBL," 1994)

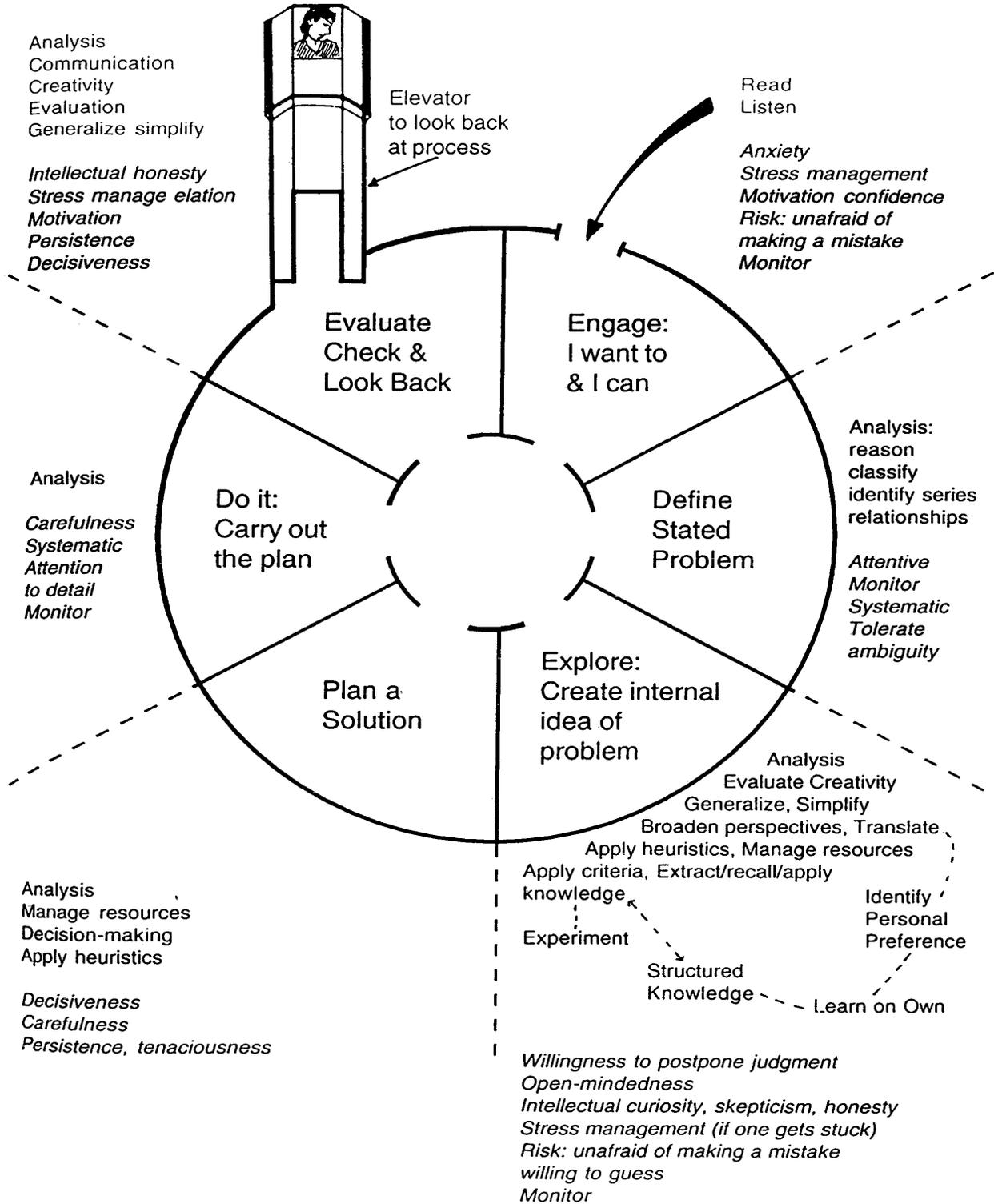


Table 4-5 Record of the Talker's strategy with ▼ for monitoring statements

Talker _____ Case _____ Listener _____

	Stage								
"Define" Assess	Read: <i>"I want to and I can!"</i>								
	Define-the-stated problem: Sort the given problem statement								
	Explore the problem to discover what the problem really is								
Plan	Plan								
Implement	Do it								
Evaluate	Look back: elaborate, check								
		0	2	4	6	8	10	12	

Talker _____ Case _____ Listener _____

	Stage								
"Define" Assess	Read: <i>"I want to and I can!"</i>								
	Define-the-stated problem: Sort the given problem statement								
	Explore the problem to discover what the problem really is								
Plan	Plan								
Implement	Do it								
Evaluate	Look back: elaborate, check								
		0	2	4	6	8	10	12	

DISCOVERY

Activity

Discovered

So what? application

MPS 4: Strategy: Example assessment tasks:

1. As a listener in the TAPPS-Whimbey pair method, the problem solver has not moved the marker. You think she is now "Exploring" whereas the marker is on "Plan". Your response is:
 - a. "Please move the marker."
 - b. Reach over and move the marker for her so that you don't disrupt her.
 - c. Forget it; she probably is "Planning."
 - d. "Are you still planning?"
 - e. "Can you check which step you are in?"
 - f. Other (provide your specific response)

2. Your task is to identify Schoenfeld monitoring activities. Which of the following actions/statements would you classify as "monitoring." Rationalize your choice for each.
 - a. the problem solver puts his hand out to move the marker and pauses.
 - b. "Let's see if I am finished with this step."
 - c. "Which step should I go to now?"
 - d. "What did I learn from that?"
 - e. "If I measure the blood pressure, that should tell me..."

3. Given the following stage-time chart as evidence, to what degree can you claim to have achieved the goals of this workshop? Write out your discussion of this evidence.

4. From the in-class activity, you have the following evidence:
 - your reflections that you wrote three times during the activity.
 - your worksheets and the statement of the exercises.
 - the strategy stage-time chart including the monitoring notations.
 - the DISCOVERY sheet.
 - your awareness and skill checklist **before** and **after** the activity.

Write up a reflective assessment of the degree to which you have achieved the objectives. Refer to the evidence by number and relate your evidence and claims to the objectives by number.

MPS 4: Strategy timing sheets For an abbreviated 1½ h version see PBL: Resources to gain the most from PBL” pages B-16 or B-21 <<http://chemeng.mcmaster.ca/innov1.htm>> problem based learning.

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Topic	Trans- par- ency no.	Time, min	Elapsed time, min	Comment
1. Introduction	1	2	2	Use anteater cartoon to introduce the unit if the participants have not previously seen it.
2. Where it fits in	2	0.5	2.5	Always include this type of overview to show the big picture
3. Pretest	3	0.50	3.	Unlike other pretests, here the participants can write in the strategy that they currently use
4. Objectives	3	3	6	Read over, or have one person at a time read these over. Do not expect comprehension at this time. Tell them this. Do not give excessive elaboration yourself.
5. Route ahead	4	1	7	
6. Example data	5	1.5	8.5	Show 5 and 6 simultaneously on the two overhead projectors
7. Example process	6			
8. Example strategy	7	3	11.5	Show 7 and 8 simultaneously on the two overhead projectors; you role play the talking and marker; then role play the listener recorder
9. Example listener evidence form	8			
10. Option selecting strategy: criteria	Opt 9	2		You can use any strategy you want. The key skills we are developing are being organized, systematic, having a strategy and monitoring. We don't want to get hung up arguing about the strategy. For example, for workshops with nurses, use the 4-step Nursing process of Assess, Plan, im0plement, evaluate. <i>However, for this activity, the talker and the listener must agree on the strategy. Furthermore, we have invested several years of research to develop the MPS 6-step. The purpose of this series of optional transparencies is to share that research and to get a buy-in for the strategy board in transparency #7</i>
11. Option research	Opt 10	1		
12. Option		2		you might display some of the 75+ published strategies
13. Option results	Opt 11	2		

Topic	Trans- par- ency no.	Time, min	Elapsed time, min	Comment
14. Option importance of defining problems and what we do during the process	Opt 12	2		
15. Option visual reinforcement of three phases to <i>DEFINE THE PROBLEM</i>	Opt13	2	22.5	
16. Activity: boredom		3	25.5	If you used the options, then the 20 min attention span is exceeded. Include back rubs, handshakes, stretches, or “Turn to a neighbor &... discuss the strategy you use”
17. Seek agreement and understanding of terminology for the strategy board	Opt 14	1.5	13 27	
18. Leader explanation of activity and roles	Opt 15	1	14 28	An option would be to provide written description of roles and ask each to read the role. This should go quickly <i>if the participants have experienced the MPS I Awareness unit</i> . If they have not experienced it, then you need to spend more time.
19. Getting ready.	16	2	16 30	This is a paper shuffle. However, this needs to be done carefully so that each person retains evidence of his/her work.
20. Activity: pairs TAPPS	17	7-12	26 40	Flexible time here. 7 min minimum to 12 min. choose a time to match the breaks. You want to complete activity #23 before the break.
21. Reflection, discussion	18	3	29 43	
22. Activity: pairs TAPPS	19	7-12	39	Flexible time: choose the time to match breaks
23. Reflection, discussion	20	3	42	
USUAL end of a 50 min class				
24. <i>Research</i> Internal representation	21	1	1	Important concept; basis for the Explore stage

Topic	Trans- par- ency no.	Time, min	Elapsed time, min	Comment
25 <i>Research</i> importance of the three stages to DEFINE THE PROBLEM	22	2	3	To some extent, this is a restatement of 14 and 15. However, since this was in the options, include it here even if you did the option. Here more detail is given.
26. <i>Research</i> Larkin's data about reading the problem statement	23	1	4	
27. <i>Research</i> Schoenfeld's research about monitoring; table	24	2	6	
28. <i>Research</i> Schoenfeld's data	25	0.5	6.5	
29. <i>Research</i> Schoenfeld; data	26	0.5	7	
30. So What? Activity with monitoring	27	1.5	8.5	Show transparencies together
31. Gathering evidence of monitoring	28	1.5	10	
32. Activity: TAPPS	29	7-12	20	repeat activity with subject discipline detective stories; timing given is based on 10 min.
33. Reflection	30	3	23	
34. Activity :TAPPS	31	7-12	33	repeat activity with subject discipline detective stories; timing given is based on 10 min
35. Reflection	32	3	36	
36. Feedback from Schoenfeld's data	33	2	38	show simultaneously; the first few minutes in Schoenfeld's data shows "exercise solving"; then with extensive exploration, the problem solver is showing "problem solving"
37. Problem solving versus exercise solving	34	3	41	
38. Problem solving	35	3		Option depending on time: these are useful in that they show the relationship between exercise solving and problem solving; the relationship between textbook knowledge and knowledge structured for problem solving; and between experience and memorized solved problems
39. Exercise solving	36	3		Option depending on time

Topic	Trans- par- ency no.	Time, min	Elapsed time, min	Comment
40. Reflection & discuss	37	3		Option depending on time
41. Posttest and objectives	38	4	45	MUST to close out unit
42. DISCOVERY	39	5	50	MUST to close out the unit
total			50	

MPS 28 Group skills

Donald R Woods, McMaster University, Hamilton

CANADA

Jan., 2001; April 2002

Developing group skills starts with an awareness and application of the Seven Fundamental Rights of all persons:

R be **R**espected
I to **I**nform others about your own opinions
G to have your own personal **G**oals and needs
H to **H**ave feelings and to express them
T to have **T**rouble, make mistakes and be forgiven
S to **S**elect or choose whether you will meet another's expectations

and

not to achieve your rights by violating the rights of others

In North America, four behaviours that can destroy an effective group are:

- contempt
- criticism
- defensiveness
- withdrawal or "stonewalling"

Next, we should be aware of how to give and receive feedback. Suggestions about how to do this effectively are given in Chapter 5 from "Problem-based Learning: how to gain the most from PBL".

MPS 28: Group skills © copyright, Donald R. Woods, 1999

Group skills: application of problem solving and interpersonal skills to efficiently and effectively complete a task & develop good morale among the group members.

Skill development:

1. Learn the characteristics of groups and how the characteristics evolve as the group matures.
2. Realize that each person has a unique contribution to the group process; that contribution should be encouraged, nurtured and used to the advantage of the group.
3. Learn how to give and receive feedback .
4. Recognize that trust is the most valued element in relationships and be able to list those behaviours that build trust and those that destroy it .
5. Acquire some skill at listening
6. Acquire some skill in assessment
7. Realize that both morale and task are important
8. Realize that groups always perform better with a chairperson
9. Accept that chairperson is not leadership. Leadership varies from person to person depending on the task.
10. Accept that if a group is faltering, process skills are needed. Gradually you will develop skill in facilitating the group process.
11. Through self awareness, begin to improve self confidence
12. Begin to develop an environment of trust where risking is OK.
13. Group skills are the first step toward developing team skills
14. Be able to identify the different elements that make up “group norms” and recognize the importance of discussing these early in the group process.

Pretest:

Group skills how aware are you of what you do in a group? Rate with an “x”

0	1	2	3	4	5	6	7	8	9	10
Unaware				Aware of					Very aware	
I just				Some					I can describe	
do it									The details of	
									how I do it	

Skill: how skilled are you in contributing positively to the task and morale of a group? Rate with an “x”

0	1	2	3	4	5	6	7	8	9	10
Poor		Fair		Good			Very good			Excellent

Comments:

1.1 given a term listed under "concepts introduced", you should be able to give a word definition, list pertinent characteristics and cite an example.

2.1 given a problem, as a member of a group, you will participate in the task and morale components of the process such that your participation will be judged by an observer to be "active" and to have more positive than negative contributions.

2.2 as above but your performance will be judged to be "most of these skills" for both task and morale by two independent observers.

2.3 given a problem, the group will complete the assigned task by the designated time and over 60% of the members of the group will choose to work together again.

2.4 given a group solving a problem, you will be able to observe the group, record plus and minus contributions toward both task and morale components. You will be able to do this observing an individual client or the group as a whole. Your records will agree to within 80% of the average records made by four other observers or with those of the tutor.

2.5 as a member of an observer group, you will be able to provide written suggestions on how the group can improve its task and morale components. Eighty percent of your recommendations will agree with those of the tutor.

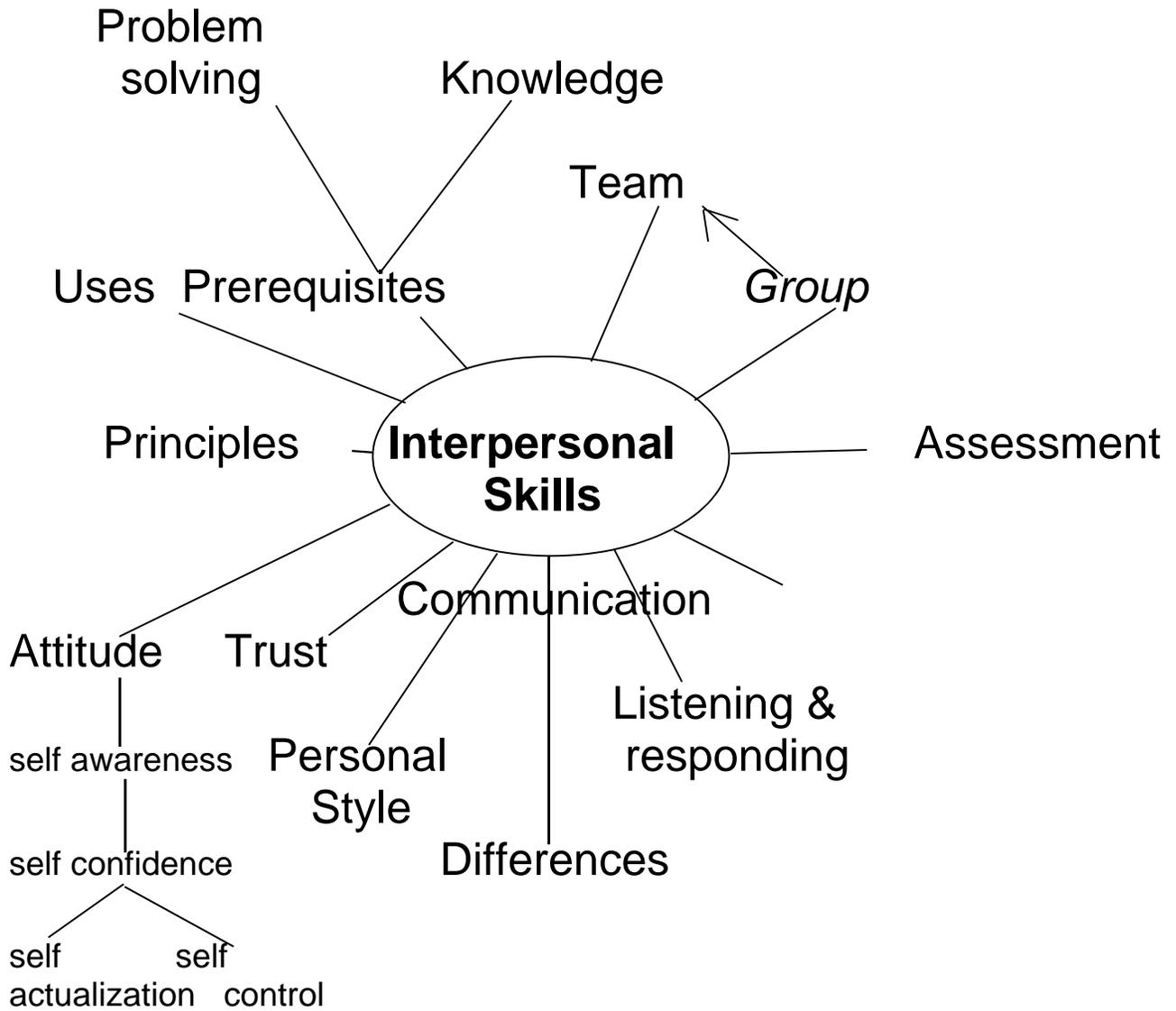
2.6 as a member of a group solving a problem, you will be able to self assess the performance of the group. Your assessment should agree within 80% of the assessment of outside assessors.

2.7 as in 2.6, you will be able to self-assess your personal contribution to the task and morale components of the group process. Your assessment should agree within 80% of the assessment of an outside assessor.

Concepts introduced

Task and the positive and negative contributions toward task, Morale and the positive and negative contributions toward morale, FIRO-B, stages of group evolution, feedback form.

MPS 28: Group skills *Where it fits in*



Evidence-based targets for group skills (reprinted from references 4,17) Form **2800** .

Evidence-based targets	Progress toward internalizing these targets				
	20%	40%	60%	80%	100%
● Performance improves when we have goals. ^[18]					
● Assessment must be related to the goals ^[19]					
● Both Task (getting the job done) and Morale (feeling good about the group work and about how you have interacted with the other group members) are important ^[19]					
● Any group functions better with a chairperson ^[20]					
● Chairperson and leadership are different; different people may become leaders at different times. ^[20]					
● Group evolution tends to follow a pattern described as by such descriptors as “forming, storming, norming and performing” ^[19,20] . Schutz’s instrument FIRO-B ^[12,21] seems to provide reliable insight as to the personal style of individuals towards other group members during three of these phases.					
● We can list the roles needed in both Task and Morale to make an effective group. ^[19]					
● When each person has a clear idea of roles and group norms, the group functions better. ^[19]					
● When groups are functioning effectively, about 70% of the time is spent on the task; 15% on morale building activities and 15% of task process activities (how the problem solving process is going; summarizing ideas, guiding the process). ^[22]					
● The products from groups or teams is improved when members have different “styles” (in Jungian terminology some members are dominant S, and some, dominant N). The products from groups tend to be inferior when all the members “think and behave alike”. ^[23,24, 19,20]					
● The quality of decisions, product, task is improved if group members offer different perspectives, disagree and seem to introduce conflict into the process. The trick is to manage the apparent conflict well. ^[19,23,24]					
● The characteristics of “meetings of individuals,” “effective groups” and “teams” fall on a spectrum with sufficient differences that it is useful to differentiate based on those characteristics					
● In a decision-making mode, after 20 minutes of discussion on any one topic, few new ideas are presented and repetition of previously stated ideas occurs. ^[25]					

Feedback about the group work. Form **2802**

Observation Form **2801**

Observer _____ - Client _____ Case _____

Task		Group members					
Task process observer; (problem solving process)	Orients group, monitors, summarizes, seeks direction, identifies phases +						
	Ignores phases, asks whatever wants, blocks, unaware of contributions -						
Information or Opinion Giver (related to task)	Assertively gives information, makes suggestions +						
	Withholds information, silent, aggressive, passive -						
Information or opinion Seeker (related to task)	Asks questions, checks comprehension +						
	Silent, refuses to ask questions -						
Energizer Risk taker	Enthusiastic, introduces a spark, novel ideas +						
	Follower, agrees, silent unsure -						
Morale							
Observer of interpersonal process	Sensitive to interpersonal dynamics, comments on what's going on +						
	Ignores conflict, tension, hopes it'll go away -						
Giver of praise and support	Warm, responsive, gives help, rewards +						
	Put downs, aggressive, self-centered, defensive, critical, contemptuous -						
Interpersonal problem solver: Seekers solutions	Mediates, harmonizes, helps resolve conflicts +						
	Causes problems, seeks personal goals -						
Energizer tension relief	Jokes, laughs, shows satisfaction +						
	Withdraws, causes tension -						

Strengths

Areas to work on

Observation Form **2801**

Observer _____ - Client _____ Case _____

Task		Group members					
Task process observer; (problem solving process)	Orients group, monitors, summarizes, seeks direction, identifies phases +						
	Ignores phases, asks whatever wants, blocks, unaware of contributions -						
Information or Opinion Giver (related to task)	Assertively gives information, makes suggestions +						
	Withholds information, silent, aggressive, passive -						
Information or opinion Seeker (related to task)	Asks questions, checks comprehension +						
	Silent, refuses to ask questions -						
Energizer Risk taker	Enthusiastic, introduces a spark, novel ideas +						
	Follower, agrees, silent unsure -						
Morale							
Observer of interpersonal process	Sensitive to interpersonal dynamics, comments on what's going on +						
	Ignores conflict, tension, hopes it'll go away -						
Giver of praise and support	Warm, responsive, gives help, rewards +						
	Put downs, aggressive, self-centered, defensive, critical, contemptuous -						
Interpersonal problem solver: Seekers solutions	Mediates, harmonizes, helps resolve conflicts +						
	Causes problems, seeks personal goals -						
Energizer tension relief	Jokes, laughs, shows satisfaction +						
	Withdraws, causes tension -						

Strengths

Areas to work on

Case 1: **The Fishing Trip** (from C.E. Wales)

It was the first week in August when six friends set out on an overnight fishing trip in the Gulf of Mexico. Everything went well the first day - the sea was calm, they caught fish and later camped out on a lovely little island. However, during the night a very strong wind pulled the anchor free, drove the boat ashore and the pounding waves broke the propeller. Although there are oars in the boat, the motor was useless.

A quick review of the previous day's journey showed that the group was about 80 km from the nearest inhabited land. The small deserted island they were on had a few scrub trees and bushes but no fresh water. They knew from their portable AM-FM radio that the weather would be hot and dry, with daytime temperatures expected to be over 35°C the rest of the week. They are all dressed in light clothing but each had a windbreaker for the cool evenings. They agreed that whatever happened they would stick together.

The families back on shore expected the group to return from their trip that evening and would surely report them missing when they didn't show up. However, they realized that it might take time for someone to find them because they went out further than anyone might have expected.

Items available	Rating
<i>Each person has</i>	
a. one windbreaker	
b. one poncho	
c. one sleeping bag	
d. one pair of sunglasses	
<i>The boat contains</i>	
e. a cooler with 2 bottles of pop/person plus some ice	
f. one large flashlight	
g. one first-aid kit	
h. fishing equipment	
i. matches, rope and a few tools	
j. one compass mounted on the boat	
k. two rear-view mirrors which can be removed from the boat	
l. one official navigational map of the Gulf area where you are	
m. one salt shaker (full)	
n. one bottle of liquor	

Case 2: Crash land in the Canadian subarctic

You and five other passengers are in a plane flying toward Schefferville in the subarctic when you crash-land 100 km away from Schefferville. You are on dry land yet there are at least nine water crossings on a direct line between you and Schefferville. The only means of navigation you have is a small, difficult-to-read map although you have a compass. The immediate area is covered with small evergreen trees and the terrain is hilly and rocky with moss covering the perma frost. The temperature today is 2 °C and the weather conditions are for colder air in the next week. The next airplane expected is in 3 days. There is a 800 m high hill about 2 km away, and this might put you in the line of sight with the Schefferville airport. The prevailing winds are 24 to 28 km/h. There is an abandoned mine 5 km away but off the line of sight of an airplane going to or from the airport. The plane is wrecked but before it burned up you are able to rescue the following 15 items. You all decide to stay together whatever you do. Rate the items of relative importance to you with 1 meaning the most important.

	Rating
a. 13 wood matches in a metal screw top waterproof container.	
b. a fifth of Bacardi rum (151 proof) in a glass bottle	
c. three pairs of snowshoes	
d. one sleeping bag per person (arctic type, down-filled with liner)	
e. a gallon can of maple syrup	
f. a magnetic compass	
g. a 7m x 7m piece of heavy duty canvass	
h. an operating, 4 battery flashlight	
i. safety razor kit with a mirror	
j. a hand axe	
k. a large bottler of water purification tablets	
l. 80 m of 1 cm diameter braided nylon rope, 25 kg test.	
m. a book entitled "Northern Star Navigation"	
n. a wind-up alarm clock	
o. one aircraft inner tube for a 35 cm diameter wheel; punctured.	

Case 3: NASA Problem

You are a member of a space crew originally scheduled to rendezvous with a mother ship on the lighted surface of the moon. Due to mechanical difficulties, however, your ship was forced to land at a spot 350 km from the rendezvous point. During landing, much of the equipment aboard was damaged, and since survival depends on reaching the mother ship, the most critical items available must be chosen for the 350 km trip. Below are listed the 15 items left intact and undamaged after landing. Your task is to rank order them in terms of their importance to your crew in allowing them to reach the rendezvous point. The most important is rated #1.

Items available	Rating
a. box of matches	
b. food concentrate	
c. 15 m of nylon rope	
d. parachute silk	
e. portable heating unit	
f. two 0.45 calibre pistols	
g. one case of dehydrated milk	
h. two 50 km tanks of oxygen	
i. stellar map of the moon's constellation	
j. life raft	
k. magnetic compass	
l. 10 L of water	
m. signal flares	
n. First aid kit containing injection needles	
o. solar powered FM receiver transmitter	

Case 4: The Case of the Reluctant Fluidized bed (J. Sweetman, McMaster)

The fluidized bed is used to dry damp solids powder. The feed contain 5% water. The feed is a potash muriated from four large centrifuges. The potash enters the bed from a feed screw. A knife gate is used to maintain the bed height in the fluidized bed.

Fresh air is brought in from outside, heated in a natural gas burner and distributed through tuyeres at the bottom to fluidize the bed. After about one week of operation, the operator claims “even though the air flow is at the desired level, the flow starts to decrease, the bed collapses and the whole unit shuts down. We then have to dig it out and start all over again. “ This is intolerable. Fix it.

Case 5: Terry sleuth and the case of the recirculating blower.

Harold whipped through the last calculations of the power required for the gas recirculation blower on the catalytic reactor. “Let’s see, that’s finished - calculate the density of the gas via the ideal gas law based on the temperature, pressure and composition of the recirculating gas, multiply the actual volumetric flow for the recirculation conditions to get the ideal power required. A reasonable value....Oh, Hi, Terry.. I’m just finishing up the design calculations for the new reactor.”

Terry Sleuth looked over Harold’s shoulder. “That’s the recirculating system operating predominantly hydrogen being recirculated at 150 °C and 12 kPa pressure gauge” “Right! replied Harold. “I was just saying that I adjusted my ideal power calculation by dividing it by a reasonable value for the motor-blower efficiency. I used 60%.” Terry Sleuth perused the calculations done so far. To Harold’s surprise, the Sleuth cautioned “I don’t think we’d better install the motor based on your calculations.”

Case 6: The reluctant Pump

A centrifugal pump has been installed to pump water from a holding basin through a filter and on into the process. We often bypass the filter and just pump out of the basin to an atmospheric drain. The system head curve (and thus the design conditions) is 12.5 L/s against a total head of 10.5 metres. A pump has been selected to operate most efficiently at this condition. Everything works fine when the liquid is directed through the filter. However, when we bypass the filter and try to pump out the basin we can only pump down to a water level of 3.3 metres below the centreline of the pump. This leaves 1.2 metres of water in the bottom of the basin that can’t be pumped out.

Form 2802

Task: Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. Group applied successive approximation and optimum sloppiness. Group avoided contributing excessive information.

None of these behaviours	Few of these behaviours but major omissions	Most features demonstrated	All of these behaviours
<input type="checkbox"/> 1	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 6
<input type="checkbox"/> 2	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 7

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

None of these behaviours	Few of these behaviours but major omissions	Most features demonstrated	All of these behaviours
<input type="checkbox"/> 1	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 6
<input type="checkbox"/> 2	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 7

Individual Contribution to Task and Morale

Group Strengths

Group Areas to work on

<hr/>	<hr/>
<hr/>	<hr/>
<hr/>	
<hr/>	

Reflection:

6-40

DISCOVERY

Activity

Discovered

So what? application

MPS 28: Group skills: Example assessment tasks:

1. Watch the videotape of a group meeting and use the feedback form given in Table 1 to assess the performance of each group member and the group as a whole. Note the five strengths of the group and the two areas to work on.
2. The following are the results of FIRO-B for Andre.

4	7	4
8	3	7

- a. Assume that this is a reasonable description of Andre; how is Andre likely to behave in a group?
 - b. Based on your own FIRO-B, compare your responses with those of Andre and suggest how you and Andre might interact from at least four different points-of-view: inclusion, control, affection, expressed toward others and wanted from others.
3. You have just joined a PBL group. They have found out that you have had some training in group process. They ask you to "tell them how to improve their group skills." Summarize the key ideas about group process.
 4. You have just joined a PBL group. They have found out that you have had some training in group process. They ask you to "give us some training in group skills." Prepare a workshop. Estimate the time required, outline the activities, highlight the main points you want them to focus on.

7. How to manage the transition to PBL?

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Case 5: *The letter to the Dean.*

You have been five years in a tenure-track position. You have 15 refereed publications with 4 others in the mill. You have 2 Master’s students and 2 PhD students plus a large series of grants to keep your research program viable.

Your teaching has received “fair” ratings from the students in the past. last year the Chair suggested that you might devote a little time to improving your teaching. Indeed, the Department sent you on two workshops: one on cooperative learning and the other on PBL. These were very motivating. You saw that you could introduce PBL to part of your course 393. You added cooperative learning to each tutorial and you took a four week section of the course and converted it to PBL. It is now six weeks into the term. The Dean invites you to see him and gives you a copy of the following letter:

Oct 15

Dear Dean Habizz

We the undersigned represent 82% of the students in Course 393. The professor is incompetent! The professor is not doing the job. The professor should be fired. We are paying big bucks to come to this Polytechnic. We demand that you replace this teacher with one who knows how to teach.

- | | |
|--------------|--------------------|
| H. Andre | B. Carruthers |
| A. Sabina | Z. Gafter |
| R. Gottz | H. Dominik |
| F. Goamm | P. Sellers |
| R. Jones | S. Havaman |
| K. Sigvaler | G. Dykkno |
| K. Armstrong | D. Chang |
| A. Siggs | 43 more Signatures |
| P. Scripps | |

Activity: In small group of 5 or 6, with chair _____;
reporter _____, brainstorm the issues this case raises. Identify what you know already.
Identify what you need to learn.

Prioritize the issues: criterion: what do you want to gain from this workshop in the context of the issues raised.

—

Feedback about the group work. Form **2802**

Task: Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. The accuracy in the group's answer matched the time available. Group avoided contributing excessive information.

None of these behaviours	Few of these behaviours but major omissions	Most features demonstrated	All of these behaviours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	6	7	

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

None of these behaviours	Few of these behaviours but major omissions	Most features demonstrated	All of these behaviours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	6	7	

Individual Contribution to Task and Morale

Group Strengths

Group Areas to work on

Feedback from the Goals Meeting

Case 5:

Issues

Number identified: 1 2 3 4 5 6 7 >7

Agreement with tutor <50% 50% 60% 70% 80% 90% 100%

Knowledge/skills to be learned

Consensus among group little some a lot complete

Agreement with tutor's list little some a lot complete

Learning objectives

Quality poor fair OK good excellent

Learning

Quality of questions asked during the teach session none some astute excellent

Willingness to continue to contribute <50% 50% 60% 70% 80% 90% 100%

Your Attitude

Perry shift 2 3 3.5 4 4.5 5

Reflections:

Managing the transition to PBL

PBL can be an extremely effective learning environment. Nine issues related to the fundamental underpinnings of PBL make it effective. If these nine issues are not handled well, then the transition to PBL will be challenging!

1. Teachers ready?
2. Students ready?
3. Appropriate version of PBL
4. PBL well-designed? Know the reason why you select PBL and include keys to improve student learning: active, coop, prompt feedback, expect success, ownership
5. Students accountable?
6. Lifelong learning developed?
7. Problems mirror professional practise?
8. Process skills applied, extended?
9. Assessment done astutely?

1. Teachers ready?

The potential issues are:

Role in conventional	Role in self directed students learning
source of “knowledge” “Sage on the stage”	coach of learning process “ Guide on the side” cheerleader, mentor

Perceived control in conventional programs	Perceived control when empower students
over student behaviour:	make individual behaviour visible; provide “norms”
over standards of student performance: I set and mark the exams	monitor and assess the self-assessment process used by students
over content: “cover material”	“covering material” is not student learning;

Conventional	Self-directed learning
Teacher has intrinsic motivation of synthesizing new perspectives of the new knowledge	Teacher’s joy comes from student accomplishment
Power of all eyes on you; students writing down your every word; you are centre stage	You are coach, in the wings; encouraging and applauding
Student feedback about superstar teachers; awards	more challenging for students to give you credit.

So what might you do?

1. Select one issue in self-directedness with which you are comfortable.
2. Check for consistency with your attitude: use the inventory MRIQ.
3. Set yourself up for success. Whatever approach to PBL you take, give your interventions the best chance to succeed. Whenever you try something new, most students resist.
 - *Students prefer the familiar* to something new. They know the “lecture system” and how to make it work for them to get the highest marks. If we change the familiar “system”, most resist the change (Benvenuto, 1999). When they experience change, students often follow the eight-step grieving process of shock, denial, strong emotion, resistance, acceptance, struggle, better understanding and integration (Woods et al., 2000a; Woods, 1994). To help them through the process, run a workshop.
 - *Start small*. Call it a “pilot project”. Start where you are. Don’t wait for others.
 - *Explain why* you are making the change.
 - *Help students see their personal benefits* of the new approach in the short term and in the long term.
 - *Explain your role*. Students may believe that they are paying for teachers to “lecture.” (Benvenuto, 1999). Use Perry’s inventory (Perry, 1970, described in Woods, 1994; Woods et al., 2000a) to help students understand their perceptions; explain your role in terms of the Perry model.
 - *Monitor the program frequently*. Use ombudspersons or one minute papers (described in Felder et al., 2000) and adjust in response to their feedback.
 - *Be flexible*. If this particular class is vehemently opposed to the new approach, explore options to achieve your goals and theirs. Perhaps scale down the intervention. Gather data on how to make the intervention more effective the next time you try it.
 - *Bring in success stories*. Invite recruiters or students, from other programs where the intervention has been effective, to give testimonials at the start of your course.
 - *Help students cope with the upheaval when old habits are identified and changed*. This is particularly true for problem solving. For example, part way through a program to develop problem solving, students complained that “*focussing on the process of problem solving has meant that they could no longer solve problems.*” We used the following analogy to help them through this frustration.
Consider that you are a reasonably good tennis player. You go to an expert to improve your game. The expert takes your game apart. As you relearn how to do each part, your game is not what it used to be. Be patient. Gradually you improve and surpass your past skills.
4. Realize you will probably follow the grieving process as you make the shift. (The “Grieving process” is given in Chapter 1 of Woods, “How to gain the most from PBL” and in Workshop #4).

2. Are the students ready?

Some issues:

- a) Are students ready? do they know what it is? What is PBL? Show videotape of PBL: New Mexico, MPS *Run an Example Workshop*:

b). Are students ready? know what is expected? Manage the change? awareness of expected roles of student teacher: traditional versus self-directed. Use of Perry inventory. grieving process if there is a mis-match.

Example Workshop on Managing change: This is a double winner because it 1. helps them (and you) with PBL or any other change; and 2. empowers students with skills to manage change in the future professional career and life.

c). Are students ready? maturity? Do the students have the self confidence and maturity to handle the new empowerment accountability? Bandura (1982) studied self confidence, what it is and how you develop it. He found the following differences between self confident persons and those who had little self confidence.

Self confident	Low self confidence
Prepare	Avoid
Focus on the “tough stuff”	Hope it doesn’t happen
Persevere	Give up
Manage stress	Stress debilitates
Focus first on the familiar	Focus first on the “strange”
Positive self talk	Negative self talk

He found that an environment to develop self confidence provides rewards for performance; highlights the positives achieved because those with low self-confidence will tend to become despondent and self-devalue. The presence of highly competent individuals undermines the effective use of routine skills by others.

To develop self confidence Bandura (1982) recommended enactive mastery via workshops > observe models perform the task > emotive strategy to tell yourself you can do it > cognitive strategy. Stress is related to self confidence. We have found that helping individuals identify their “uniqueness” is very helpful. Training students to self assess is another activity that increase self confidence. In general, the stages in developing self confidence might follow the following pattern:

- Self awareness.
- Aware of what others do.
- Acceptance of self and others.
- Cognitive and attitudinal shifts related to stress management: positive self talk, learn to say NO; worry about what have control over; sense of being in control; willingness to risk
- Attitude about assessment. Receiving ± and responding to feedback. (Perry level 5)
- Aware of models of behavior: observe, and become aware of the *target skills*.
- Successfully complete achievable goals posed by others with +ve feedback from others (as is done in workshops).
- Set achievable goals and self assess.

Some ideas on helping students move toward self confidence:

Awareness: know what you do

1. Awareness of what I do? Talk Aloud Pairs Problem Solving (TAPPS), reflect. (Workshop 2)

2. Aware of others? TAPPS, reflect, peer feedback
3. Receive feedback from trained observers. Know goals in performance
4. Be aware of target behaviours: communication, listening, giving and receiving feedback, problem solving, group work, change management, self assessment.
5. Use diagnostics to know unique style where there is no right / wrong.

Example diagnostics

<p><i>Indicators of PS</i> Heppner PSI Rotter locus of control Kolb-Basadur strategy application KAI-Basadur for creativity Billings-Moos Decision-making style Risk Kellner-Sheffield Holmes-Rhae</p>	<p><i>Indicators of learning style & writing exams</i> Visualizer-verbalizer-symbol LASQ deep versus surface Jungian typology, MBTI Kolb learning cycle Perry Alpert Haber Anxiety Achievement</p>
<p><i>self directedness</i> Perry</p>	<p><i>Group and interpersonal</i> FIRO-B Johnson's conflict resolution Jungian Trust</p>

Example: Jungian typology, MBTI: your preferred style in four dimensions. This set of dimensions suggests approaches to problem solving, potential conflict with others who have different style, your style in responding to conflict, how you study for exams, taking lecture notes, your approach to trouble shooting & decisions, the challenge to teaching others in coop learning or PBL.

Example: use for teamwork: For the members of your team list values of Jungian typology and Kirton Inventory. Identify: blind spots for your team areas where there might be apparent conflict

M	S (N)	T (F)	I (E)	P(J)	KAI
you					
Mike					
Sue					
Marie					
Jose					

Example: teaching in PBL: For the members of your team list values for Perry, LASQ, Jungian S, Jungian T . For each person, identify - their learning expectations, - blind stops for identifying learning issues, - test question preparation or concept map. Critique a “teach handout”

	Perry	Strat.	Rote	Meaning	S	ST,NT,SF, NF
you						

6. Use self-assessment, reflections, personal enrichment projects.

d). Are students ready? skills

Problem solving? team work? self-assessment? Run a series of workshops: (Workshops 2,4)

Define skill
 Rationalize
 Put in context
 Pretest
 Goals, criteria, evidence
 Route ahead
 Activity <-> Feedback
 Target skills/ behaviours
 Activity <-> Feedback
 Posttest
 Summary DISCOVERY

3. Appropriate version of PBL Select PBL form for YOU and your purpose

1. Chickering & Gamson +

Improve learning:

1. active
2. cooperative
3. quality of teach-learn interaction
4. prompt feedback
5. time on task
6. environment expects success
7. personal learn style
- +
8. assessment by students
9. published goals/criteria
10. attention span = 20 min
11. wait time before answering 20 s
12. knowledge/skills/attitude

2. Ramsden & Entwistle

Deep learning:

1. good teaching
2. openness to students
3. freedom to choose
4. clear goals & standards
5. vocational relevance
6. social climate
7. (-workload)
8. (-use of formal lectures)

Select a version of PBL to improve learning & develop deep learning.

PBL: pose problem 1st. Motivates, knowledge structure: Many options. *challenge*: problem solving skill, cues.

Self-directed: students own. LLL skills. Many options. *challenge*: accountable.

Self assessed: students create & do assessment. Many options.
challenge: you monitor process.

Small group: active, prompt, coop, learning styles. Many options.
challenge: make it do this.

SG,SD,SA interdependent PBL:

4. Is the version of PBL used well-designed?

Then.. it's going to create knowledge structures that are cued for future professional recall; improve learning; promote deep learning; develop lifelong learning skills, and extend and develop "process skills".

5. Are the students accountable?

- Make student performance visible;
- Expect completion of forms relating to contributions
- Assessment journal writing
- Use self assessment

Work together. Teach <-> learn

Monitor

6. Are lifelong learning skills developed?

This is how I view it:

"Lifelong learning is assuming responsibility for identifying what one needs to know, creating learning goals and criteria, identifying pertinent and accessible resources, engaging in learning the knowledge especially the difficult parts, integrating the new knowledge with past knowledge and experience, using the knowledge to solve the need and assessing the degree of comprehension. One will use people and peers as resources."

dependent -> independent ->interdependent learner

Treat the development of this skill the same as any other:

explicit goals

<http://www.chemeng.mcmaster.ca/innov1.htm> click on PBL and download Chapter D of Resources.

Criteria; gather evidence, present an assessment journal.

7. Do the problems mirror professional practise?

How to create a problem

- 1.contains "cues"; correct learning objectives.
2. triggers pertinent previous knowledge.
3. complexity OK.
4. requires integration across disciplines & knowledge, skills, attitudes.
5. allows openness.
6. motivational; similar to future professional practice.
7. promotes student activity.

8. identifies context;
- concrete scenario;
 - clearly identifies expected task.

Great advantage of PBL is that the students learn knowledge in the context of future need. This way the new knowledge is “cued” to aid recall.

Pick representative, realistic professional problems.

8. Are the process skills applied, extended?

Ideally students have “good” skills in
problem solving,
group work,
self assessment.

We want to explicitly extend and further develop the skills as they use them in PBL.

Ideas:

- ask them to write reflections,
- elaboration at the end of the case,
- assess team work after each meeting,
- build on self and peer assessment skills.

9. Is the assessment done astutely?

A definition of Assessment is..

“a judgement based on the degree to which goals have been achieved based on measurable criteria and pertinent evidence.”

Five principles:

1. Based on performance... not personalities.
2. Based on evidence... not feelings.
3. Done for a purpose with clear performance conditions.
4. Done in the context of published goals,
measurable criteria
agreed-upon forms of evidence.
5. Based on multidimensional evidence.

Enrichment:

1. Please help me understand how best to help you
2. MRIQ

3. Jungian typology and scoring
4. Example data for 2nd year students in engineering program

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Woods, D.R. "They just don't pull their weight," Chapter 22 in "Problem-based Learning: case studies, experience and practice," P. Schwartz, S. Mennin and G. Webb, Kogan Page, 2001 highlights the effective use of peer and self assessment to improve the accountability within the group.

Helping students gain the most from their PBL experience

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Chapter submitted to the book “**The PBL book: the transformation process to PBL**” Erik de Graaf and Anette Kolmos, eds. Nov 9, 2005

We have been using small group, self directed, self assessed, interdependent problem-based learning in one of our courses since 1982, and as part of two of our courses since 1990. We chose to use PBL because it improves student’s learning, it is one of the best ways that we know of to develop lifelong learning skills, and it gives us an opportunity to develop student’s skill in group process, being a chairperson, communication, self assessment, learning/teaching and to develop their self confidence.

In this chapter we

1. elaborate on the form of PBL we use
2. we describe the context
3. we describe the skill development activities that we think are required before students experience PBL
4. we describe the workshops and activities we use immediately before PBL
5. we show evidence of student performance related to these activities.

1. Variations on PBL and the form we use

PBL seems to be the flavour of the month. Many claim to be using this popular educational innovation. Yet, closer inspection shows that their approach is completely different from the one reported in this Chapter. Not that there is anything wrong with that. Merely, we should have clear communication.

Most engineering faculty use problems extensively in the program. Students solve homework problems, solve problems on tests and exams and usually solve a number of projects (that may or may not involve design). So it is not surprising that many claim that they are already using PBL because they are using and assigning problems. As I see it there are different ways in which problems can be used that range from the two extremes: *problem based synthesis* to *problem-based learning*. In *problem-based synthesis*, students learn the required knowledge **before** they are given the problem, and the students are asked to synthesize previously-learned knowledge to solve the problem. Typically, students receive lectures on the subject and then synthesize that knowledge in the project/problem. A frequent response from an instructor who uses this approach is “How can the students solve problems if I haven’t given them lectures first?” In *problem-based learning*, the students are given a problem and the students identify what they need to learn and then the students learn and teach each other the new knowledge needed to solve the problem. They use the problem to drive the learning; new knowledge is learned **after** the problem is posed. This poses a problem in that, for

example, four of the programs described in a recent book on PBL are what I would call *problem-based synthesis*.

In this Chapter the focus is on small group, self-directed, self assessed, interdependent problem-based learning.

2. The McMaster engineering context

Here we describe the PBL experience in the senior year where PBL is part of a required course in an otherwise conventional program. The class size varies from 45 - 59 students with three, 50 min classes per week. PBL is used to replace the four weeks of lectures (12 hours) we used to use for the topic “Engineering Economics”. Instead, in the 12 hours of class time four short problems are presented (one each week) in the context of following topics: 1: interest/depreciation/financial statements/risk/ taxation; 2: financial attractiveness; 3: capital cost estimation; and 4: operating cost estimation. (For the timing to work out, we needed five and a half weeks). For each cycle there are three, in-class student meetings: a goals meeting, a teach meeting and an assess meeting. Students are assigned to groups of five or six. They remain with the same group for all the PBL activities. A different student is assigned to chair each meeting. The chair is expected to circulate an agenda ahead of time; to run the meeting; and, based on the feedback about performance, submit a self-assessment of his/her performance as chair.

In the *Goals* meeting the students interact with the problem and list what they know and what they need to know to solve the problem. They create about 6 to 8 learning objectives and prioritize these. To ensure that the objectives meet the needs of the program, the instructor provides written validation or, if the objectives are inadequate, he/she provides hints and new perspectives that the students can use to reconsider the problem. Once each group has approved learning objectives the group members identify resources and contract with each other as to the topics that each will research and teach.

In the *Teach* meeting, the students, in turn, hand out teach notes, interact with their peers and teach each other the new knowledge. Each receives immediate feedback as to the quality of the teach.

In the *Assess* meeting, each prepares a good, 10 minute test question (and answer) in a subject area different from their area of teaching. The group has eight minutes

to select “the best” test question. That question is given (via the instructor) to another group to solve so that all groups have a question to answer. Thus, for example, a question from group A might be given to group J. Each group has 30 minutes to write an answer. Then, a person to mark the answer (from the group that posed the problem) goes to the group identified as working on their problem; the marker marks and responds to questions from the respondee group answering the question. Thus, group A would send a marker to group J. At the end of the session, the instructor collects all the posed questions and answers from the posers and the group answers from the respondees and marks the quality of each. In some instances, the instructor adjusts the marks given to the respondees.

One week after every meeting, the chairperson submits a self assessment report on his/her acquisition of skills as chairperson. Each person also submits a self assessment report on his/her acquisition of skills in lifelong learning. Their assessments are done in the context of published learning objectives, measurable criteria and many different forms of evidence.

For nominative marks (term marks) each student receives marks, based on their self assessment report, on their skill as chairperson and as a lifelong learner including the quality of the teach notes; groups receive marks on the quality of the assess components. At the end of the course, there is a 3 hour written final examination created by both the instructor and the students. The final mark in the course is based on a student contract. The student may contract to have the term mark count as any percentage between 10 and 90%. A default option is that the student receives the best of a 40-60 split between the term and final exam mark. Details are given elsewhere [Woods, 1997b; 1996]

3. Prerequisite skill development activities before students experience PBL

In our program, prerequisite skills that the students need for effective PBL include skill in problem solving, self assessment, group process and learning. This is supplied by about 80 hours of required workshops, via the MPS program, in years 2 and 3 before they enter the PBL portions. Details given in Woods et al.1997; Woods et al., 1988, Woods and Sheardown, 2004.

4. Helping your students make the most from PBL

In addition to developing the required prerequisite skills, we introduce the PBL activity by providing published learning objectives for both the lifelong learning skills and the chairperson skills - skills that are acquired through the PBL activity while the subject knowledge is being learned. Tables 1 and 2 list these objectives. We also provide progress charts so that students can monitor the development of the target skills. Table 3 is an example. We give some practice completing feedback forms about performance related

to these skills. Table 4 is the feedback form for teaching within the PBL context and Table 5 is the form for chairperson.

We show a 23 minute videotape of students participating in the three meetings: goals, teach and assess. Introducing the learning objectives, discussing the videotape, getting familiar with the feedback forms and clarifying expectations usually takes two hours of class time.

In addition, in Option #1, we encouraged them to create a learning contract, to have a “norms” meeting and to use inventories to explore learning preferences within each group. However, we provided no class time nor did we have explicit activities. This was the option we used when we had between 6 and 8 autonomous groups.

We used option #2 when our class size increased to 10 to 12 autonomous groups. In Option #2, we added four hours of activities so that issues of learning contracts, group norms, learning preferences and how to gain the most from PBL were addressed explicitly. The details of these four are as follows:

1. Students completed the following inventories: Myers-Briggs/Jungian/Keirse (Hogan and Champagne, 1979; Keirse and Bates, 1984); Kirton KAI (Kirton, 1976), Lancaster approaches to studying (Ramsden, 1983; Woods et al., 2000) and Perry (Perry, 1970; Woods, 1997a). A workshop was used to help students see the implications and effects these results might have on their performance. Within their groups all entered the results of the inventories and discussed the implications. Example data are given in Table 6.

2. The second activity was a one-hour lecture-interaction in which we rationalized the choice of PBL as a learning environment and described the underlying principles of how case problems were created. We basically addressed the question “*What’s in it for you, the students?*”

We related how, traditionally, instructors publish learning objectives for every course and how in PBL, instead of handing students the course learning objectives, we pose professionally- significant problems that are *cued* so that the students will generate learning objectives equivalent to the instructors. Teachers monitor this process to ensure that each group is learning the “right material”. The case problem should generate about 6 to 7 learning objectives each requiring about one to two hours of “learning time” and one to two hours to create effective teach notes for a total of about 2 to 4 hours of homework per group member. This provoked a lot of discussion and very probing questions. What seemed to be helpful to the students was a sense of direction behind the activity, the teacher’s validation of the learning objectives and the clarification about the time commitment.

3. The third explicit activity was a one-hour workshop on how to search for cues, generate learning objectives, how to research and teach and how to prepare effective

teach notes.

4. The fourth activity was one hour class time for the group norms meeting and the possible creation of group contract. Each group considered 17 issues that ranged from the *method of making decisions* to the *level of intervention when apparent conflict occurs to asking a person to leave the group* (Woods, 1994a). Three groups created learning contracts during this time. An example is given in Table 7. Other groups decided to have verbal agreements; one group initially decided on a verbal agreement and later created a formal written contract.

In summary, we feel that introducing the students to PBL is very important. This includes the publication of learning objectives, practice with the assessment/feedback forms and some introduction to PBL as a learning environment. We used two options: Option #1 that required a total of two hours of in-class activities, and Option #2, requiring six hours of in-class time. Next we compare some dimensions about the impact of these two options.

5. Impact on student performance.

The students entering the PBL activity showed the following characteristics:

- both groups had about the same overall grade point average based on the previous courses that they had completed
- the students who received Option #1 had a slightly better score on the Perry inventory. This suggested that they, as a group, entered PBL with an attitude more compatible with the PBL learning environment. Those in Option #1 entered the PBL activity with an average Perry score of 3.6 with 14 % of the students having a Perry score < 3; those entering Option #2 had a slightly lower average Perry score of 3.3 with 22% of the students with a score below 3.

How did the students fare who received the different introductory experiences?

For the student performance, our focus was on 1) the quality of the subject knowledge learned, 2) the student's attitudes about PBL as a learning environment and 3) the quality of the interdependent teaching.

5.1 Quality of the knowledge learned

Some evidence related to the quality of the knowledge learned is the marks on the test questions used in the assess meetings. For option#1, the average mark for the questions posed in the assess sessions (and monitored by the teacher) = 93%; for Option #2, 97%. We conclude that there was a negligible difference between the groups as far as the quality of knowledge learned.

5.2 The attitude about the learning environment

Some evidence that we used included the Perry attitude after the PBL sessions; the observations of the tutor as he circulated among the groups, and the comments made in the individual's self assessment journals. This information is summarized in Table 8. For both Option #1 and Option #2, 25% of the students left the PBL activity with Perry scores < 4. These students had trouble shifting their attitude about their role (relative to the role of the instructor), about assessment, and about knowledge. Considering the incoming values of the Perry inventory, more students shifted their attitude when they received Option #2.

The tutor's comments were that all of the groups that received Option #2, except 5 and 10, were very strong groups. Furthermore those groups that received Option #1 tended to struggle and were not as successful in supporting each other or in trying to make PBL work effectively (as those students who received Option #2). The tutor comments were based mainly on the analysis of the self assessment journals.

The students who received Option #2, by and large, embraced the PBL experience and made it work for them. Those who received Option #1 tended to struggle with PBL - some tried to make it work; some didn't even though they entered PBL with slightly better values of Perry. The Perry inventory is helpful but this suggests that it should not be the only factor considered.

5.3 Quality of the interdependent learning

To assess the quality of the interdependent learning, evidence includes the assessments of the quality of the teaching from the form **3601** (shown in Table 4) and comments made in the individual's self assessment journals. Each receives feedback on form **3601** from every person in his/her group every time he/she teaches. Therefore, in a group of five and with three cycles of PBL, each person has 15 ratings of the *quality of knowledge* brought to the group. This is averaged for each person and averaged over all the people in the group to give a group average. This average is reported in Table 8.

For the students who received Option #1, the ratings of the quality of the teaching were relatively low on all dimensions for all groups. Only one group had a rating above 7.2/8 on the *quality of knowledge* brought to the group and no group had ratings over 7.2 for the *quality of the teaching* or the *small amount of learning on one's own* that might be needed. Even in group 6 where all students seemed committed to PBL and all had a high Perry rating, the *quality of the teaching* was higher than in other groups in that cohort but it was not outstanding.

For Option #2, all eleven groups had ratings above 7.2/8 for all dimensions.

The comments in the individual self assessment journals are too extensive to report here. Rather, some representative comments from the journals and comments by the tutor are given.

For Option #1:

Here are representative comments from student's journals:

Learning objectives were the hardest to create. I was frustrated because others didn't prepare.

Enjoyed this type of learning environment

"PBL is not as time saving as I thought." "I'm glad that I don't have to listen to lectures on this topic. I was stimulated by working with others to solve a problem under time constraints."

"PBL showed me my strengths and weaknesses in communication and expressing myself."

"Members who previously seemed disinterested did gradually become involved." "Probably the most enjoyable part of PBL was designing the test questions during the feedback session. This gave us an opportunity to explore the interrelationships among different topics."

The tutor's comments were:

For group 1, the third PBL cycle was the tough one with not all doing their fair share. The group did not confront this directly. Wide range of Perry attitude. Although learning style information was given to everyone about all the group members, these data were not formally reported or used by group. The group was too generous in ratings.

One tried but preferred lecture; two didn't try.

For group 2: the group got off to a tough start with about 3 members uncertain if this would work; somewhere between case 3 and case 4 they seemed to get their act together. However, two were ineffective in teaching others. They really couldn't get their teach skills in place.

For option #2,

Our group has continued to work at a professional level for both task and morale. Chair skills are improving with each meeting. All group members continue to put a strong effort into all PBL activities.

PBL is really suitable for me and our group. Our group is attending, thinking, friendly, willing to contribute and enthusiastic.

Overall the PBL meetings are working out very well for my group and for me. They are helping me assess the way I operate within a group and my learning style and ability. They also are a good introduction to what it is like to run a meeting with success and confidence. This PBL was very successful overall. I personally was able to make strides in my attitude and in the better completion of the objectives.

Tutor's comments: All groups worked well although group 5 struggled and one person in group 10 felt that two were not doing his/her share. In all groups students commented on their development of confidence, respect for others, and skill in teaching and in the group

process.

In summary, the quality of the interdependent learning demonstrated by those who received Option #2 was superior to the performance of the cohort of students who received Option #1.

6. Summary

We clarified our definition of PBL, described the context in which we use autonomous groups of 5 to 6 students in a senior class of 45 to 59 students. We briefly described the workshops in the second and third year to develop the background skills needed for autonomous group PBL.

Details were given of various activities teachers can use to introduce students to PBL. The short two-hour version produced inferior results compared with the longer six-hour version as measured by the attitude toward PBL and the quality of interdependent learning.

Issues other than the Perry inventory are important to address. These include identifying and exploiting personal preferences within the groups, training in how to teach, rationalizing PBL as a learning environment of choice and elaborating on the checks and balances to maintain standards and make PBL effective. Providing in-class time for a group norms meeting and the use of self assessment journals are two other important features we have found useful to help students gain the most from PBL.

Learning objectives and feedback/assessment forms were given.

7. Acknowledgements

I am pleased to acknowledge the students in our program who willingly shared their experience with us.

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Table 1. MPS 36: Lifelong learning in the context of small group, self assessed, self directed, Problem-based Learning PBL © copyright, Donald R. Woods, 1998

Lifelong learning in the context of small group, self assessed, self directed, Problem-based Learning **PBL** is as follows: given a professionally-significant problem you will identify what you know already to solve the problem, what new information you need to know, contract with other members of the group that individuals will learn different aspects of the new information and return to the group and *teach* all members of the group the new information. As a group you will use all the old and newly-learned knowledge to solve the problem. The group will elaborate on other ways to use the new knowledge.

Skill development:

1. Ability to work effectively in a group.
2. Can value the unique contributions each person brings to the group.
3. Able to deal with unexpected frustrations.
4. Able to adjust to empowerment and accountability.
5. Can identify the knowledge needed to solve a problem.
6. Able to teach one another.
7. Able to manage stress and time.
8. More skill in giving and receiving feedback.
9. Through self awareness, to improve self confidence.
10. Skill in self and peer assessment.
11. Develop trust where risking is OK.
12. Building on skill in information literacy and individual “research projects” and moving toward *reactive* lifelong learning.

Pretest:

Awareness: how aware are you of what you do when you do this ability? Rate with an “x”

0	1	2	3	4	5	6	7	8	9	10
Unaware				Aware of						Very aware
I just				Some						I can describe
do it										The details of
										how I do it

Skill: how skilled are you in doing this activity? Rate with an “x”

0	1	2	3	4	5	6	7	8	9	10
Poor		Fair		Good			Very good			Excellent

Comments:

MPS 36 Self-directed learning or lifelong learning in the context of small group, self-directed, self assessed PBL

- 1.1 given a term listed under "concepts introduced", you should be able to give a word definition, list pertinent characteristics and cite an example.
- 2.1 Given a problem, you will ask questions, explore issues so that within 30 min, as a group of five, you will be able to identify all of the five to six major issues, and these shall agree within 95% of those identified by the tutor.
- 2.2 Given a problem, you will be able to list the possible knowledge you would need to know to solve the problem; your list should agree within 80% of the list of others in your group and within 85% with the list of the facilitator/tutor.
- 3.1 Given a problem and a list of the possible knowledge and resource available, you will create learning objectives and methods of assessment. These will be 90% acceptable according to the criteria for self-performance assessment (in MPS 3)
- 3.2 Given the learning objectives and methods of assessment, you will be able to identify reasonable and pertinent sources of information and be able to allocate the resources to achieve the objectives in the time available.

3.3 Given the learning objectives, you will create for yourself examination questions that are consistent with the objectives. These will be judged by peers and or tutor to be 90% acceptable.

3.4 Given that other members of the group have acquired key knowledge pertinent to the situation, you will ask questions so that you can learn from them the knowledge you need. You will interact such that they will rate a willingness above 70% to continue to share information with you.

3.5 Given that you and your group have completed a teach meeting, you will pause and write reflections once every ten minutes about the process used.

5.1 Given that you have contracted to teach topics to meet selected learning objectives of the group, you will learn the knowledge, and with due consideration of the learning styles of other members in your group, prepare “teach notes” and use these to teach the other group members such that you receive feedback from all members of the group with ratings $> 6/7$ for knowledge and $> 6/7$ on quality of instruction.

5.2 Given the first PBL teach session described in Section 5.1 and given the feedback of your five strengths and two areas to work on, within three PBL cycles you will maintain all your strengths and shift one of your weaknesses to be a strength. The evidence will be the feedback from all the members of your PBL group.

5.3 Given the initial problem and the solution to the problem (from 3.6), you and the group will elaborate in writing to identify at least thirteen different perspectives. The elaboration will be assessed as being correct and enriching by the tutor or a group of peers.

6.1 Given the initial problem and the knowledge that you and the group have learned and your solution to the problem, you and the group will use the knowledge to solve the problem. You and the group will self assess that the problem solving process, the answer to the problem and lifelong learning was the best you could do with the time available.

6.2 Given the feedback from a Perry inventory, you will be able to judge the degree to which this assessment is valid; you can list the five strengths and two areas to work on such that in a cycle of six PBL sessions you will shift such that a retest using the Perry inventory will show a rating of > 4 for all dimensions of the inventory.

6.3 Given skill in self assessment (MPS 3) you will create a learning journal in which you record and self assess your progress as a self directed learner. This will be assessed once per month by a peer, mentor, tutor to be “satisfactory”.

Concepts introduced

Peers as resources, Perry's inventory, reflection, elaboration, learning objectives, assessment.

Elaboration: is the creation of a new perspectives of the ideas learning, the problem solved and the relationship of the new ideas to previous experience. Elaboration includes activating previous knowledge and searching for connections between previous and new knowledge. Elaboration includes determining the details of the new knowledge, creating examples, analogies, restatements, conditions, deductions and simplifying and generalizing. Elaboration includes searching for similar concepts and noting confusing elements, similarities and differences.

Table 2

MPS 29: Chairperson skills © copyright, Donald R. Woods, 2005

Chairperson skills: facilitation skills used so that a group applies problem solving and interpersonal skills to efficiently and effectively complete a task & develop good morale among the group members.

Skill development:

1. Learn the characteristics of groups and the role of the chairperson to facilitate group evolution to a team.
2. Realize that each person has a unique contribution to the group process; that contribution should be encouraged, nurtured and used to the advantage of the group. The chairperson is to facilitate this encouragement, and nurturing.
3. Learn how to give and receive feedback .
4. Recognize that trust is the most valued element in relationships and be able to list those behaviours that build trust and those that destroy it .
5. Acquire some skill at listening
6. Acquire some skill in assessment
7. Realize that both morale and task are important
8. Accept that chairperson is not leadership. Leadership varies from person to person depending on the task.
9. Accept that if a group is faltering, process skills are needed. Gradually you will develop skill in facilitating the group process.
10. Through self awareness, begin to improve self confidence
11. Begin to develop an environment of trust where risking is OK.
12. Group skills are the first step toward developing team skills
13. Be able to identify the different elements that make up "group norms" and recognize the importance of discussing these early in the group process.

Pretest:

Chairperson skills how aware are you of what you do as chairperson of a group? Rate with an "x"

0	1	2	3	4	5	6	7	8	9	10
Unaware I just do it				Aware of Some						Very aware I can describe The details of how I do it

Skill: how skilled are you as chairperson? Rate with an "x"

0	1	2	3	4	5	6	7	8	9	10
Poor		Fair		Good			Very good			Excellent

Comments:

MPS 29 Chairperson skills

1.1 Given a term listed under "concepts introduced", you should be able to give a word definition, list pertinent characteristics and cite an example.

5.1 Given that a chairperson is assigned to the group and that, for growth, the chairperson will receive feedback from every group member at the end of each meeting, all will have practice completing form **2901** (Feedback to chairperson) such that there will be no more than 1.8 scale variations on the rating of Task and of Morale among all the raters and the Total ratings (about

the role of the chairperson) will not deviate by more than 10 among all raters. The ratings will also agree with those of a trained outside assessor.

6.1 Given a group, you will facilitate a **norms** meeting so that the group unanimously decides on the typical 17 issues related to group process. These range from *the role of the chairperson* to *procedure for asking a person to leave the group*.

6.2 Given a group and a decision that has to be made (and perhaps the process to be used to make the decision, eg, vote, consensus, unanimity, nominal group), and given the feedback from form **2901** from all the participants, you will be able to objectively summarize the findings, extract a description of the role you played, contrast the descriptors the members give you with the ones you wrote in the pretest and write out an action plan to help you improve. Your analysis of the evidence should agree within 80% of that of the tutor.

6.3 Concerning the assessment of the group and of the chairperson using form **2901**, given the same group functioning under different chairpersons at different times and with different tasks, as a group you will consistently rate the group's performance on Task and Morale and consistently discriminate between the group's inherent ability and the chairperson's contribution to the group. The consistency will be within 1.8 units on the 7 point scale used on form **2901**.

6.4 Concerning improvement, given the assessment in #6.2, and given other opportunities to be chairperson, you will convert at least one of your "Areas to work on" into a "strength".

6.5 Given that you are to chair a meeting and given the purpose, you will prepare an agenda and circulate it to all attendees at least 48 hours ahead of the meeting. The agenda shall include names, time and place of the meeting, purpose, prework that is expected of all participants, a list of materials and information to bring to the meeting, a list of the topics to be addressed at the meeting and the time allocated for each item. An outside observer or tutor should assess the agenda as being 100% complete.

6.6 Given that you are to chair a meeting and given the purpose, you will prepare an agenda, devise ahead of time whatever materials you feel need to be brought to the meeting, circulate (at least 48 hours in advance) the agenda to all interested parties, run the meeting and complete 60% of the agenda in the time available and receive better than average ratings on both task and morale for the conduct of the meeting and receive a total rating on task (the sum of the totals from all group members on chairperson feedback form) > 30 and > 30 on morale.

6.7 As in #6.6, but complete 80% of the agenda and receive total ratings for each Task and Morale of >100

6.8 As in #6.6, but complete 100% of the agenda and receive total ratings for each Task and Morale of > 300.

Concepts introduced

Agenda, norms meeting, feedback form **2901**, chairperson, leader, Task, Morale, Sanderson's 20 minute rule, vote, unanimity, nominal group, consensus.

Table 3 MPS 36 Lifelong learning skills

Evidence-based targets for lifelong learning. Although some general principles have been reported that relate to lifelong learning, most of the target skills are based on best practices as recommended by researchers.

Lifelong learning is learning how to learn so that whatever comes our way we empower ourselves to master new knowledge. Evidence-based targets	Progress toward internalizing these targets				
	20%	40%	60%	80%	100%
1. Consider peers and classmates as resources to help me see my learning needs, plan my learning and provide new ideas so that I can learn from them.					
2. Able to assess learning needs realistically.					
3. Able to create observable, unambiguous and achievable learning objectives to match or satisfy my needs. I use these to assess my progress.					
4. Can relate to teachers as resources, facilitators and helpers rather than as the sole source of knowledge. Have acquired an attitude toward learning comparable to Perry level 5.					
5. Able to identify people and material resources needed to achieve my learning objectives.					
6. Able to shift from being a dependent learner through being an independent learner to being an interdependent learner.					
7. Able to devise a time plan and stick to it reasonably well.					
8. Willing to assume responsibility and ownership for the tasks in learning, including goal setting, resource identification, learning and assessment.					
9. Able to meet contract commitments to teach others.					
10. When teaching others, able to use the principles of learning and address differences in learning styles (instead of <i>reporting information</i> and expecting the learner to sort it out.					
11. When learning a difficult topic, am willing to accept the challenge to unravel the complexity - instead of skipping over it and <i>hoping it won't be on the exam.</i>					

Table 5: Form 2901 Chairperson Feedback

Date of meeting: _____ Group: _____ Chairperson: _____

Agenda circulated ahead of time, yes no ; start on time, yes no ; end on time, yes no

●**Task:** Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. The accuracy in the group's answer matched the time available. Group avoided contributing excessive information.

None 1 Few but major omissions 2 Most features demonstrated 3 Most features demonstrated 4 Most features demonstrated 5 All of these behaviours 6 All of these behaviours 7

Total _____	Agenda: Names, time, place, purpose, prework, bring, topics, timing	Use of agenda: Keep on topic, effectively & not disruptively keep on time, 20 min rule	Facilitation as needed when team functioning below norms on Task
15 to 20	Excellent & ahead of time	Used very well	Mega positive: clarified, brought back on task, monitored Task
10 to 14	Poor & ahead of time	OK	Some positive as needed: clarified, back on task, monitored Task
5 to 9	Excellent but handed out at start	Fair	Neutral because working well
0 to 4	Poor and handed out at start		
0 to -4	Excellent created at start	Poorly	Neutral when help was needed or unskilled and unable to facilitate
-5 to -9	Poor created at start		
-10 to -15	No agenda	Not used	Kept dominating as leader, when facilitator need, Solved problem for group, when they didn't want that solution
-16 to -20			Mega negative, imposed own ideas and answers. Dictator

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

None 1 Few but major omissions 2 Most features demonstrated 3 Most features demonstrated 4 Most features demonstrated 5 All of these behaviours 6 All of these behaviours 7

Total	Agenda:	Use of agenda:	Facilitation as needed when team functioning below norms on Morale
15 to 20	Excellent & ahead of time	Used very well. Comfort high because know goals	Skilled observer of interpersonal process, praiser, facilitates, conflict resolution and provides tension relief as needed.
10 to 14	circulated ahead but missing prework & bring	Comfort moderate, can infer what to do ahead of time	Some skill and intervention
0 to 9		Fair	No intervention because all working well
-1 to -9	Some frustration; feel ill-prepared because didn't know what to prework or bring	Poor	No intervention when help was needed or unskilled and unable to facilitate
-10 to -15	No agenda, High distress	Not used, high distress because unclear as to where going	Some, causes lower-than-norm morale because of criticism, defensiveness, contemptuousness, stubborn, conflict
-16 to -20			Mega causes tension, seeks personal goals, critical, abusive, self centered and defensive, contemptuous, ignores others

Personal Satisfaction with decisions made: 0 extremely dissatisfied...5 OK..... 10 very satisfied

●**Strengths**

Areas to work on

Instructions: as an individual rate the **Task** elements of the meeting.

Then consider the role the chairperson played by circling the appropriate descriptor in each column for the three elements: agenda, use of the agenda and facilitation. Total the corresponding numerals from the LH column. Example: excellent agenda but handed out at start (7); fair use of agenda (5), neutral because working well (2) for a total of 14. Repeat for the **Morale**. Score your personal satisfaction with the decision made: numeral out of 10; List five strengths and two areas for the chairperson to work on.

Table 6 Example of Individual learning styles and preferences

	Jungian typology				Lancaster approaches to studying			Perry	KAI
	S	T	E	P	strategic	rote	deep		
Self	25	24	28	10	14	16	15	3.5	78
John	22	21	15	15	14	18	16	2.8	100
Karen	27	24	23	16	19	15	19	3.9	100
Rob	18	23	29	23	11	17	16	3	102
Sarah	21	26	24	14	14	19	17	3.3	86

Table 7, Example learning contract (reprinted with permission from Karen Rogers, Jeff Bunn, Deirdre Schroder, Ben Yue, Craig Lee and Deepti Asthana, copyright 2005)

LEARNING CONTRACT

1. When a decision is to be made between two things. A coin will be flipped to decide. When more than 2 things need to be decided, rock paper scissors shall be played., best 2 out of 3.
2. Respect deadlines and everyone will arrive on time.
3. Respect others opinions.
4. Everyone will come prepared.
5. Agendas will be e-mailed before 9pm prior to the next meeting.
6. If a person is falling behind, others will try to help them accomplish said persons goals. Help must be asked for in advanced.
7. People shall attempt to remain positive.
8. We agree to try to remain on topic during meetings and not go off on tangents.
9. If you have something you feel need's to be said, say it.
10. The chair should make deadlines clear to the team.
11. On teaching days, small handouts should be giving to teammates highlighting key aspects of the talk.
12. Before adjourning the meeting, a clear outline of what is required for the next meeting will be given by the chair for that meeting.

If you deviate from these 12 objectives the following consequences will result:

1st offence = A friendly reminder and you must bring 6 donuts to the next meeting.

2nd offence = A written letter signed by the members of the group and bring 6 donuts again.

3rd offence = "The Letter"

Group Member Signatures:

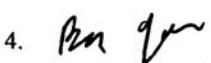
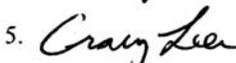
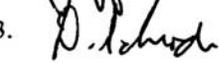
- | | |
|--|--|
| 1.  | 4.  |
| 2.  | 5.  |
| 3.  | 6.  |

Table 8 Summary of Tables comparing Option # 1 with Option #2

Option # 2					
no. students with Perry no.		Rating out of 8 from Form 3601			Comments
Group	< 3	< 4	knowledge	communication	feedback required
1	0	1	7.4	7.4	7.4 Strong group
2	0	0	7.7	7.8	7.7 Strong group
3	1	2	7.5	7.6	7.2 Strong group
4	2	1	7.8	7.8	7.6 Strong group
5	2	4	7.7	7.5	7.6 Struggling group
6	3	0	7.9	7.9	7.7 Strong group
7	1	1	7.9	7.9	7.8 Strong group
8	0	1	7.3	7.2	7.2 Strong group
9	1	1	7.6	7.4	7.4 Strong group
10	1	2	7.5	7.5	7.5 Not all doing their share; one in particular
11	2	2	7.5	7.5	7.4 Diverse but productive
		>7.2	11	11	11
Option #1					
no. students with Perry no.		Rating out of 8 from Form 3601			Comments
Group	< 3	< 4	knowledge	communication	feedback required
1	2	0	7.1	7.1	7.1 Not all doing their share; two in particular
2	0	0	6.3	6.8	6.8 Two ineffective in teaching
3	0	0	6.9	6.7	6.6 Tried hard to make this effective
4	0	3	7.1	7.1	7 inadequate teaching
5	1	1	7.1	7	6.8
6	0	0	7.4	7.2	7 All committed; all Perry shifted
7	0	2	6.8	6.9	Two are not committed; no learning contract;
8	2	3	6.3	6.8	5.3 delinquent
		>7.2	1	0	0

8. How to assess student performance:

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C/PBL/wksp 6-singapore02

Case 6: In this PBL approach, the students are teaching each other. How do we know if they are learning it correctly? Many of my students don't even understand it from my lectures, so how can they "teach" someone else?

Besides how do I assign a mark for each student. Some are scholarship students. I better give them a 3 hour exam."

Activity: In small group of 5 or 6, with chair _____;
reporter _____, brainstorm the issues this case raises. Identify what you know already.
Identify what you need to learn.

Prioritize the issues: criterion: what do you want to gain from this workshop in the context of the issues raised.

Feedback about the group work. Form **2802**

Task: Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. The accuracy in the group's answer matched the time available. Group avoided contributing excessive information.

None of these behaviours	Few of these behaviours but major omissions	Most features demonstrated	All of these behaviours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	6	7	8

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

None of these behaviours	Few of these behaviours but major omissions	Most features demonstrated	All of these behaviours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	6	7	8

Individual Contribution to Task and Morale

Group Strengths

Group Areas to work on

Feedback from the Goals Meeting

Case 6:

Issues

Number identified: 1 2 3 4 5 6 7 >7

Agreement with tutor <50% 50% 60% 70% 80% 90% 100%

Knowledge/skills to be learned

Consensus among group little some a lot complete

Agreement with tutor's list little some a lot complete

Learning objectives

Quality poor fair OK good excellent

Learning

Quality of questions asked during the teach session none some astute excellent

Willingness to continue to contribute <50% 50% 60% 70% 80% 90% 100%

Your Attitude

Perry shift 2 3 3.5 4 4.5 5

Reflections:

—

Activity: a perfect circle

Discuss with neighbour what's going wrong in this scenario

1. What is assessment?

Use a framework of assessment for the accountability. Five principles and Six issues in practice.

Five Principles:

Principle 1. Assessment is a judgement based on performance - not personalities. We need to help a student realize that a poor mark does not mean he/she is a bad person. The judgement is made about performance in completing a task. It has nothing to do with his/her value as an individual. This is an issue, especially for students with attitudes characterized by Perry's level 2.

Principle 2. Assessment is a judgement based on evidence - not feelings. We might intuitively feel that a student is a good problem solver. However, we need to replace that intuitive feeling with physical evidence such as the written script on an exam or in a project report. Help the students (and staff) gather evidence. Provide time for students to write reflections. The staff responsibility is to create well-designed standardized feedback/assessment forms. Provide practice understanding the terms and working with the forms **before** the program.

Principle 3. Assessment should be done for a purpose with clearly-defined performance conditions. The student should know when he/she is being assessed.

Principle 4. Assessment is a judgement done in the context of published goals, measurable criteria and pertinent, agreed-upon forms of evidence. Use research, not personal intuition, to identify the target skills. Publish goals with measurable criteria for process skill. Such goals should provide clear needs for documented evidence. These should be published at the start of the program so that there are no surprises for the students and no unwanted student backlash to the teacher.

Principle 5. Assessment should be based on multidimensional evidence: static and dynamic situations; small assignments and lengthy projects; academic, social and personal contexts; under a variety of performance conditions (exams and homework, written and oral, performance as an individual and as a member of a group,) formative and summative data and with different persons being the assessors (self, peer, teacher and trained external observers).

To remove ambiguity from the assessment the following six *issues in practice* should be addressed (Alverno, 1985, Woods, 1994).

1. Goals: What is being assessed? Knowledge in engineering or a discipline subject? Skills? Attitudes? Have the goals been expressed unambiguously in observable terms? Who creates the goals? Are the goals explicit and

published?

2. Criteria: Are there criteria that relate to the goals? Can each criterion be measured? Who creates the criteria? Are the criteria explicit and published?

3. Form of evidence: What evidence is consistent with the criteria? Are the checklists used for the assessment asking questions related to the criteria? Do both the assessor and the student know that this form of evidence is acceptable?

4. Resources: Are the goals and the collection of the evidence possible to achieve in the time and with the resources available?

5. Assessment process: What is the purpose of the assessment? Under what conditions is the student's performance assessed? Who assesses? What type of feedback is given by the assessor? (For example, Pass fail? a grade? five strengths and two areas to work on?) What is the form of feedback? Verbal? Written? What is the timing of feedback? Who delivers the feedback?

6. Training in the assessment process: Have both the student and the assessor received training in assessment?

Additional Ideas:

Provide ± feedback; not just -ve.

Guideline: Use 5:2 ; 5 positives for every 2 areas to improve.

Gibbs "Whoever owns the assessment owns the learning."

Student misconceptions; Agent 100% "Licence to pass" & Perry level 2.

2. What to assess?

Subject knowledge

"Process skills"

- identify issues
- goal setting
- locate information
- critically assess
- written/oral communication
- lifelong learning skills
- problem solving
- group skills
- self/ peer assessment
- analyze/ create
- deal with conflict

Activity:

For your PBL course or assuming you are going to use PBL next term as an individual: what % of the emphasis is on the development of "process skills".

% Subject knowledge _____

% Process skills _____

3. Set goals and criteria

Goals:

List Target skills (based on research not intuition)

Make them Observable and unambiguous

Levels of development: start with simple and achievable. Bloom's taxonomy is a good guide.

Numerous: guideline for a course: 30

“Process” or “product”

Criteria:

Must be related to the goals: don't download “metrics” from www.

Need to measure.

Challenge: “ *answer should agree 100% with that of the instructor*”. Rarely is this stated in undergraduate courses, so... when we need to create them in “soft skills” or “thinking skills” it usually is a challenging task. (Took us 13 years to create a set for 52 process/thinking skills)

Example: Team Skills: Goals

Level 1: To be able to characterize and diagnose effective interpersonal skills and effective groups and to become aware of the personal role one typically assumes in group work. To set goals for group growth.

Level 2: To build up individual skills and apply them effectively to group work. The individual skills include self awareness, self acceptance, acceptance of others, and self confidence, conflict resolution, listening and responding , decision making and assertiveness.

Level 3: To build up individual skills and apply them effectively to group work. The individual skills include chairperson skill, reaching consensus, goal setting and coping with difficult behaviours.

Level 4: To integrate and apply the skills to team development through benchmarking, diagnosis, and implementation of plans for growth.

Example Team skills:

MPS 28: Group skills © copyright, Donald R. Woods, 1999

Group skills: application of problem solving and interpersonal skills to efficiently and effectively complete a task & develop good morale among the group members.

1.1 given a term listed under "concepts introduced", you should be able to give a word definition, list pertinent characteristics and cite an example.

3.1 given a problem, as a member of a group, you will participate in the task and morale components of the process such that your participation will be judged by an observer to be "active" and to have more positive than negative contributions.

3.2 as above but your performance will be judged to be "most of these skills" for both task and morale by two independent observers.

3.3 given a problem, the group will complete the assigned task by the designated time and over 60% of the members of the group will choose to work together again.

3.4 given a group solving a problem, you will be able to observe the group, record plus an minus

contributions toward both task and morale components. You will be able to do this observing an individual client or the group as a whole. Your records will agree to within 80% of the average records made by four other observers or with those of the tutor.

6.1 as a member of an observer group, you will be able to provide written suggestions on how the group can improve its task and morale components. Eighty percent of your recommendations will agree with those of the tutor.

6.2 as a member of a group solving a problem, you will be able to self assess the performance of the group. Your assessment should agree within 80% of the assessment of outside assessors.

6.3 as in 6.2, you will be able to self-assess your personal contribution to the task and morale components of the group process. Your assessment should agree within 80% of the assessment of an outside assessor.

Concepts introduced

Task and the positive and negative contributions toward task, Morale and the positive and negative contributions toward morale, FIRO-B, stages of group evolution, feedback form.

Activity:

As group of _____ create a learning goal at Bloom’s level _____ to identify skill expected in “_____”

Example: Level 1: Knowledge

Level 2: Comprehension

Level 3: Application

Level 4: Analysis

Level 5: Synthesis

Level 6: Evaluation

4. Forms of evidence:

For some skills, activities, performances we need

“Observation forms” that are well-designed:

- valid (measures the goal),
- reliable (different people using the same form will give the same results),
- easy to use.

Should provide training in its use.

Valid: published goals, specify levels of performance along appropriate continuum scales, compare ratings with other data

Reliable: clear goals, clear criteria for levels of performance, train raters

Ease in use: consider Likert type scale.

Some example forms of evidence:

Reflections
Reflective learning journal
Portfolio
Workshop activities
Peer and self assessment
Oral presentation
Written presentation
Tests & Exams in Process Skills, TEPS

5. Assessment: who does the assessment?

Self

Peers

Tutor

Student Misconceptions
Not licence to give yourself 100%, Not Agent 100
Based on the Fundamentals
Provide workshop training in how to do an assessment

Student expectation: and attitudes about their role and teacher role
Attitude: Perry Scale

Activity Example: “Self assessment”

Goals: observable, unambiguous, published (Where going)

Criteria: measurable, related to goals, published (How know when arrived)

Performance evidence: published, well designed

Enrichment:

1. Please help me understand how best to help you

2. MRIQ

3. See Workshop #2 for a set of Assessment-Feedback forms.

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Assessing team skills. Part 1: successful teams

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Abstract

The five principles of assessment are summarized. The evolution from a cluster of people to an effective group to a team is described. Goals and criteria are given for effective teams. Nine options for gathering evidence are described. Actions to implement a program to improve group skills are listed.

Keywords

Assessment, group work, teams, research on effective groups, rating forms, ABET 2000, program outcomes.

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Laboratory work, design projects, cooperative learning - many learning situations are used where students are expected to work in teams. Group work is used 1) to prepare students for the future (where they will be expected to work in teams), 2) to save faculty marking time, 3) to minimize laboratory equipment and the number of experiments that are needed for laboratory work, 4) to improve learning by having students work cooperatively instead of competitively, 5) to allow faculty to assign more ambitious projects and 6) to develop team skills. An analysis of the future of engineering education suggests that skill in working in teams is needed by our graduates.^[1] For example, ABET Engineering Criteria 2000 criterion^[2] 3.d requires that we show that our graduates have “an ability to function on multidisciplinary teams.” An effective team has been defined as “a group of people who work together toward a common vision and accomplish extraordinary results.” Francis and Young^[3] suggest that teams “succeed despite difficulties and with members feeling responsible for the output and acting to clear difficulties standing in the way.”

Unfortunately, most students do not develop team skills from being put on a team and asked to “be a team.” Just placing students in groups or teams does not automatically develop group skills. Student dissatisfaction is usually high because everyone gets the same mark even though some team members believe that they contributed more to the project than did others. Some students hide in the group or just fail to be responsible to the group. They don’t do any work and/or they fail to come to meetings.

In this paper, we review the principles of assessment, differentiate between effective groups and teams, list goals and criteria for effective teams, and suggest options for gathering evidence. Actions to implement a program to develop overall effective teams are given. In the next paper in this series, Part 2, we consider how empowerment and accountability are linked, list goals for the personal development of team skills, list some example options for gathering evidence and give some example data.

For ABET purposes and to improve our educational efforts we also want to evaluate the effectiveness of our programs to develop team skills. More details are given in Part 2.

1: Principles of Assessment

We find it useful to remind students of the elements of assessment. Students often view assessment as the process of “*trying to figure out what the instructor wants.*” We define assessment as “a judgement based on the degree to which the goals have been achieved using measurable criteria and pertinent evidence.” We have found that breaking this definition into five principles assists in applying this definition. The five principles are:^[4-7]

Principle 1: Assessment is a judgement based on performance - not personalities. We need to help a student realize that a poor mark does not mean he/she is a bad person. The judgement is made about performance in completing a task. It has nothing to do with his/her value as an individual. This is an issue, especially for students with attitudes characterized by Perry’s level 2. More details about Perry’s levels and their implications to teaching and learning are given elsewhere.^[4,8,9]

Principle 2: Assessment is a judgement based on evidence - not feelings. We might intuitively feel that a student is skilled at team work. However, we need to replace that intuitive feeling with physical written evidence.

Principle 3: Assessment should be done for a purpose with clearly-defined performance conditions.

Principle 4: Assessment is a judgement done in the context of published goals, measurable criteria and pertinent, agreed-upon forms of evidence.

Principle 5: Assessment should be based on multidimensional evidence: static and dynamic situations; small assignments and lengthy projects; academic, social and personal contexts; under a variety of performance conditions (exams and homework, written and oral, performance as an individual and as a member of a group), formative and summative data and with different persons being the assessors (self, peer, teacher and trained external observers).

To remove ambiguity from the assessment, the following six *issues in practice* should be addressed.^[4-7]

1. Goals: What is being assessed? Knowledge in chemical engineering? Skills? Attitudes? Have the goals been expressed unambiguously in observable terms? Who creates the goals? Are the goals explicit and published?
2. Criteria: Do the criteria relate to the goals? Can each criterion be measured? Who creates the criteria? Are the criteria explicit and published?
3. Form of evidence: Is evidence consistent with the criteria? Do both the assessor and the student know that this form of evidence is acceptable?
4. Resources: Are the goals and the collection of the evidence possible to achieve in the time provided and with the resources available?
5. Assessment process: What is the purpose of the assessment? Under what conditions is the student's performance assessed? Who assesses? What type of feedback is given by the assessor? (For example, Pass/ fail? A grade? A list of the five strengths and two areas to work on?) What is the form of feedback? Verbal? Written? What is the timing of feedback? Who delivers the feedback?
6. Training in the assessment process: Have both the student and the assessor received training in assessment?

Failures of assessments to accomplish their purpose can usually be traced to violations of any one of these five principles or to the incorrect application of the six issues in practice. The major challenges students have seem to be:

- Students can understand goals and objectives for subject knowledge. "*It's Chapter 3 in the text.*" or "*It's like the assignments we've had, only changed a little (at least we hope it is changed only a little).*"

But how do you assess teamwork? An answer is that we need to create easy-to-understand and demonstratable goals.

- Students underestimate the importance of evidence. Furthermore, they have trouble seeing the types of evidence that might be useful.

2. Groups versus Teams.

A team is not just a collection of individuals. It is more, much more. It is useful to differentiate between collections of individual efforts, group work and team work. Table 1 summarizes some of the key features. Often when we ask students to work together as "teams" they function as collections of individuals. Getting collections of individuals to function as *effective groups* is a challenge. Our experience is that, after at least two courses in which students receive explicit training on how to work together effectively^[10], the best we seem to be able to achieve is for 10 groups working effectively as groups with occasionally two of these working as effective teams. In our experience, the transition is challenging because:

1. groups evolve through the stages of forming, storming, norming and performing.^[4] Some groups, after four weeks, are still in the transition between forming and storming. They never reach "performing".
2. providing training in self assessment, goal setting, conflict resolution and sharing information about personal styles (such as Kirton's KAI,^[11] Schutz's FIRO-B,^[12] Jungian Typology,^[13] men and women in

conversation ^[14]) is time consuming and often viewed initially by teachers and students as being a “waste of time”. Later they realize how important this information and skill are for group work. For groups to learn cooperatively, we have found it useful to use the Perry inventory ^[4,8,9] and the Lancaster Approaches to Studying ^[15] to give the needed underpinnings for effective interpersonal interaction. Without such training, the transition from “collections of individuals” to “groups” or “teams” is very difficult.

3. few people are skilled chairpersons. Research has shown that every group performs better with a chairperson. , and people have not developed strong skills as chairs/facilitators of the group or team. A chairperson’s role is to facilitate the completion of the designated task while maintaining high interpersonal morale among all group members. The chairperson usually thinks through the tasks to be done, decides on the need for a team meeting, identifies the time and place for the meeting, sets and circulates an agenda, and facilitates the meeting.

4. the distinction between chairperson skills and leadership skills needs to be made. Whereas one person is assigned to be chair each meeting, leadership changes from time to time as the team work progresses. The leader is the person who has the most to contribute to the meeting at one particular time. For example, an immediate task that occurs in a meeting might be to develop a plan. The person with extensive experience in planning usually “leads” the team at this time. Another example might be that the group is experiencing conflict. Usually the chairperson will “lead” the group at this time. However, if another member of the team has extensive experience in coping with conflict, that person might “lead” at that time. Any team member can be a “leader” depending on the group needs.

5. the only motivation most students have for trying to work effectively in groups is marks. If the marks are assigned for just the product produced by the group and no individual accountability is required, then the individual effort needed to make the group work effectively is often not made by all members.

Contrast this with most business and corporate environments; those that do not shape up are shipped out.

Since a major challenge seems to be to get groups working effectively, the prime focus in this paper is the assessment of effective groups. The ideas can be extended to teamwork by changing the targets, the forms of evidence gathered and the criteria for assessment.

Ultimately we want to improve, assess and evaluate the effectiveness of developing an individual’s skill in team work. However, we need to know the overall team’s effectiveness first and help each individual understand his/her role in the team. We consider assessing the overall team in this paper and assessing the individual skill in Part 2.

3: Publish Goals and Criteria for Team work

Consistent with Principle 4, goals should be published to describe the target skills and attitudes of successful teams. (In Part 2 of this paper, we consider skills and attitudes for successful team players.) Although initially we might be satisfied with a general objective ^[16] like “able to function well on multidisciplinary teams” we have found it extremely helpful, especially for the purposes of assessment, to elaborate on the skill. Such elaboration should be based on research findings ^[10] about the performance of effective teams and effective individual contributions to teams. Here are some options for creating goals and criteria for effective teams.

- *Create a list of descriptors of effective groups or teams*

An example list for a Team consists of two elements: the “process” Task (or problem solving process used) and Morale. Process **Task**: *“the problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Group refrained from early closure. The Task was carried out and the group “looked back” and checked that the result matched the goal and seemed feasible. The group agreed on the goals. The Task process was “active” with frequent monitoring. The task was completed on time. The group applied successive-approximation and optimum sloppiness. The group avoided contributing*

excessive information.” **Morale:** *“The group was relaxed and enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment openly and directly. The seven fundamental RIGHTS of individuals were preserved. Members were enthusiastic. Trust is growing.”*

A disadvantage of this approach is that few criteria are included. For example, without published criteria one observer might judge that “trust is growing” whereas another assessor might decide that “trust is decreasing.”

- *Create a list of target skills and attitudes for the team:*

An example list for team skills is given in Table 1. ^[17-25] As with the previous option no criteria are given.

- *Provide a structured list of goals moving from beginning to advanced.*

The following set of levels can be used as a general guideline for growth.

Level 1: All members meet together, spend time getting to know each other and gaining respect for each other’s perspectives. Some are apathetic. The group sets realistic goals for improvement and makes some progress toward achieving the goals; the distinction between chairperson and leadership is still confusing but the members are willing to work toward better understanding. Members tend to hope that conflict does not occur and hesitate to apply conflict resolution techniques and assertiveness. Decisions tend to be made by consensus. Decision making is characterized as being “acceptable but inadequate.” The progression through “form, storm, norm, perform” is slow and painful.

Level 2: All members meet together. Few are apathetic. Generally all accept the goals, some may be unsure of their role in the group, the chairperson is developing his/her skill; good understanding of the differences between chairperson and leadership. Leadership does not shift smoothly as the group process evolves; often discussion and conflict occurs over who is leader “now.” Decision making is by formal votes. The group has some methods for coping with conflict and attempts are made. The group remains reticent to welcome conflict. Trust is developing. Not all are involved. The group still prefers to have members with similar styles. The progression through “form, storm, norm, perform” is reasonably competently done.

Level 3: All members look forward to meeting together. They unanimously agree on the goals, each is clear about roles, the chairperson leads the “process” very well (circulates clear and detailed agendas, focuses on and is skilled in applying the process), there are no fights for leadership; leadership shifts. The group makes decisions by unanimity. The team welcomes differences because “using different perspectives improves the product.” If differences do not occur naturally then someone willingly plays the Devil’s advocate or skeptic to challenge “group think” and bring in other perspectives. Trust is high, all are involved and accountable. Unique skills of individuals are used effectively; empathy is high. They work rapidly through the process of “form, storm, norm and perform.”

- *List component skills and create sets of behavioural, unambiguous goals with measurable criteria for each.* For example in the McMaster Problem Solving program, ^[10] MPS, the four levels of development are:

Level 1: To be able to characterize and diagnose effective interpersonal skills and effective groups and to become aware of the personal role one typically assumes in group work (MPS 3, 52, and 28). To set goals for group growth, some goals might be:

After the first meeting of the group, the group will write down five strengths and two areas to work on. 80% of these match those written by an external observer.

As a group, over a sequence of five meetings the strengths will be maintained and one area to work on has been shifted to be a strength. The assessment will agree with that of an external assessor.

Level 2: To build up individual skills and apply them effectively to group work. The individual skills include self awareness, self acceptance, acceptance of others, and self confidence (MPS 1, 4, 11), conflict resolution (MPS 49), listening and responding (MPS 26), decision making (MPS 24) and assertiveness (MPS 44).

Level 3: To build up individual skills and apply them effectively to group work. The individual skills include chairperson skill (MPS 29), reaching consensus (MPS 57), goal setting (MPS 54) and coping with difficult behaviours (MPS 46).

Level 4: To integrate and apply the skills to team development through benchmarking, diagnosis, and implementation of plans for growth (MPS 53 on teams and MPS 58 on leadership).

Each of the 15 plus component skills has about a dozen objectives, published measurable criteria and example assessment tasks. ^[10,17,26]

The use of the last approach - identifying goals for team and team development - and the explicit development of the component skills has the advantage of individual accountability and ease in assessment of individual skill development. More is discussed in Part 2 of this paper.

4. Forms of Evidence: performance options to assess team work

Valid assessment is based on evidence: Principles 2 and 4. First we consider how to design a rating form. Then, we describe nine options of evidence.

● *Create a well-designed assessment or rating form for team work.*

Before any options are considered, a team rating form needs to be created. The rating form should be valid and reliable.. One of the challenges in assessment for teachers is the design of the rating form. The items included in the form must be consistent with the criteria. The rating form should not contain more items than are convenient for a rater to consider at any one time, and the form must be related to the goals and criteria which are described in some detail on the form.

An observer assessing a group should not be expected to rate more than two or three people at one time ^[27,28] and the form should be organized in convenient chunks around the main elements of the process being observed. Compare, for example, the two forms in Figure 1. Form A shows only the first entry of 26 items; Form B shows the first of 8 items. First of all, expecting an observer to keep track of and rate 26 different items is asking for super-observers. We think, in form B, that an observer has a chance to remember and rate only 8 items. Secondly, Form A places these in the category of "helpful behaviors" . Research, summarized in Table 2, reminds us that Task and Morale are the two major issues to consider in group work. These descriptors in Form A sound like task issues but "arriving on time and prepared" can be construed as a Morale issue. Such ambiguity makes it difficult for the rater. Form B, clearly identifies Task as being the issue and identifies one of four Task items for assessment. Each item can have either positive or negative contributions. In summary, form B is preferred over form A.

It is important to provide external descriptions of the criteria or standards. Otherwise, raters tend to create internal standards- standards selected based on one's own performance or a performance judged to be similar to one's own. ^[29,30] Consider Figure 2 that shows four different rating forms. Form 1 gives no

details of the goals; it only lists "effective clinician" and provides no measure of the criteria. The rater is expected to pick some number between one and ten. What is acceptable or outstanding to one rater, will be inferior to another. No standards are given, and so each rater will create personal and different internal standards.

Form 2 offers at least some description of the skill being considered: the "knowledge" that the clinician brings to the patient-doctor encounter. However, the term "knowledge" is ambiguous; different raters will use different internal criteria in choosing the box "meets objectives".

Form 3, in Figure 2, gives more description of the goals by listing three attributes under "knowledge" that an effective clinician is expected to display. Some criteria are given to help the rater understand what "meets objectives" means. However, the term "solid knowledge" and "common problems" are ambiguous. What is *solid knowledge* to one rater is not solid knowledge to another.

"I rated you low because you knew very little about diphtheria."

"Diphtheria is not a common problem in this area. Why should I be expected to know about diphtheria?"

responds the resident being evaluated.

Although form 3 is a marked improvement over forms 1 and 2, the form still has ambiguous words.

Form 4, in Figure 2, gives a more detailed and less ambiguous description of what is expected. True, a list is not given of the 38 illnesses but, at least we know that we are expected to know 38 and not just 5. This elaboration on the goal allows the rater to check or circle the particular deficiency from the list that forms the basis for the rating.

Criteria-referenced, rather than norm-referenced, assessments^[31] should be used. The use of norm-referenced assessments means that one's performance is compared to another's instead of being compared to external standards defined by the criteria. Norm-referenced leads to competition that is contradictory to the cooperative atmosphere expected of groups and teams.

Well-designed rating forms or questionnaires can be used to provide evidence about team effectiveness and be used to assess group growth. Here are nine options for forms of evidence for decision making about the overall team effectiveness.

● Option 1: ***Quality of the answer supplied.***

Teams are usually assigned a task to do. The product could be a written or oral report, a recommendation, a set of plans, goals scored in a sports game, money raised in a campaign, successful trade show or party or event. In academia, we tend to assess primarily the quality of the technical answer, design report, and lab report. If these are good, we assume the team work was good and vice versa. In the sports analogy, if many goals were scored we must have a great team. Unfortunately, this relatively simple way to assess teamwork is usually an incorrect measure of teamwork. We are using the wrong evidence. The product is not necessarily a good measure of the process. This approach is not recommended.

● Option 2: ***Individual assessment of group's accomplishment of the target skills.***

Table 2, form 2800, provides the evidence-based targets for effective groups and teams. Ask students to monitor the group's attitudes and skills. They can indicate the dates when the group achieved different degrees of exhibiting the target skills. Although some students may fake it and fill the whole thing in the night before it is due to be handed in, nevertheless, we have found this to be a very effective focal point and form of evidence. The assessors can be outsiders (non-group members) or insiders (group members self assessing their team's efforts). Dyer^[32] suggests that outsiders are usually in a better position to assess the failure to communicate, the formation of subgroups and conflict. Insiders are usually in a better position to assess levels of trust, frustration, personal cautiousness in presenting ideas and lack of

enthusiasm in attending meetings. Saavedra and Kwun ^[29] have found that outside, passive observers interpret the intergroup dynamics differently from assessors who are active members of the group. This doesn't negate the value of having external observers. However, the research suggests that groups should value feedback from both external observers and self and peers.

● Option 3: ***External assessors use a rating form for overall team work.***

Figure 3, form **2801**, can be completed by external observers to suggest the positive and negative roles different members played and to give overall strengths and areas to work on for the working group. The focus is on the Task and Morale dimensions and on effective groups (as opposed to teams). Because of the difficulty in simultaneously observing more than three people ^[27,28] and in participating in the group process, we recommend that this type of form be used by a team of external observers. For a team of five in the working group or "client" we recommend a team of five observer/assessors in the observer group or "observers". Each assessor considers the whole working group but focuses especially on two or three people. When the working meeting is over, the observer group convenes to share data. Each person in the working group has been looked at in detail by two persons from the observer group. Within a short time, the observer group can compare and summarize their findings and recommendations. We have used student groups as the assessors. The report from the observer group is usually a one-page summary form for the group using form **2801** plus one report on each student's contribution from each of the group observers original analysis form **2801**. No names identifying the observers shall be given. However, the names of each individual in the working group being assessed will be given. The instructor initials the report and passes it on to the client group. There is no direct discussion of the assessment between the client and the assessing groups. No two groups can be both the client and the observers. That is, if client group **a** is "observed" by group **b**, then group **b** cannot ask to be assessed by group **a**. We have found it is better if group **b** is assessed by a third group, group **c**.

Another option is to use external observers who have been trained in assessment. For example, the McMaster Medical School identifies interested people from the community, from the medical profession, from senior students and from faculty. These people are given an evening workshop on assessment and then, as teams of three, observe groups through a one-way mirror. The observation is for one hour with an additional one hour used for the observers to summarize their findings. The cycle is then repeated. Alverno College uses volunteers from business and from the community. ^[33]

● Option 4: ***Group self-assessment plus individual reflection of overall team work.***

Figure 4 gives a variation on form 2801 for use by the group for self assessment. This form (form **2802**) focuses on Task and Morale and on effective groups. It can be used for a 10 minute reflection and assessment at the end of each meeting. For three minutes, the chairperson facilitates the assessment of the group's ability with the task and morale components. All must agree and use the same rating for the self-assessment of the Task and Morale. Each member then has 30 seconds to state his/her personal contributions to the group process. This is not for discussion; this is just each person stating an opinion. For example, a person could say, "*I think that I aided the task when I... I was a little frustrated because I felt I had good ideas but was not given an opportunity to express them*".

During the last four minutes the group lists its strengths and areas to work on. Such evidence can be used by the group to show growth over the semester as a working group. We have found this to be an extremely powerful and useful form of assessment and evidence. We have used this in the freshman design course and the junior level project course.

Angelo and Cross ^[34] suggest Classroom Assessment Technique 47, CAT 47 on Group-work evaluations, to collect feedback about group work. They use this CAT to monitor classroom learning. We propose that groups can use such forms to monitor and provide evidence about group growth.

● Option 5: ***Individual assessment of the team.***

For those groups that have shifted from being an effective group to being a team, individual members should use form **2803**, given in Figure 5. Individuals assess the task and morale characteristics of the team, add personal comments and indicate areas for growth. We have used this form as part of the evidence in our senior design course. On the form, the individual is reminded of the forms of evidence upon which the rating is to be made.

● Option 6: *Individuals complete diagnostic tests about the team and then team members reach consensus.*

Some diagnostic tests that might be used are:

Francis and Young's 108 item inventory^[31]

Dyers' 11 item inventory (p. 69 or p. 75)^[32]

Alexander's 10 item inventory, given in Phillips and Elledge^[35]

Jamieson's 37 item inventory, given in Phillips and Elledge^[35]

Quick's 30 item inventory (p. 6 and another on p. 81)^[36]

Johnson's tests on specific attributes (trust, conflict resolution)^[37]

Scholtes's 21 item (p. 7-28).^[38]

● Option 7: *Individuals complete diagnostic test about the team and then team members reach unanimity.*

This is a variation on how to handle the individual results of the diagnostic tests listed in Option 6.

● Option 8: *Individuals complete diagnostic tests about the team and results are averaged.*

This is a variation on how to handle the individual results of the diagnostic tests listed in Option 6.

● Option 9: *Individuals write portfolios about team performance.*

Individuals could use the group goals for growth, the criteria and the amassed evidence (from forms similar to **2802**) to write a critique about team performance. Another approach is to ask groups to submit five summary reports (form **2802**) for each of five successive meetings and note the change in ratings and the shifts in strengths and areas to work on. Additional evidence can be included to support the claims.

5. Team work and project answers

Teams of engineers are formed for a purpose. The team is to solve a technical problem using their knowledge of Chemical Engineering. Hence, at least two elements should be assessed: the overall quality of the answer and the quality of the team. Evidence related to the technical answer is described in Option 1. This evidence should be obtained. The evidence suggested in Options 2 to 9 provide data important for:

● *Team growth*: setting standards, bench marking performance, setting goals and improving.

Improvement follows the principles of assessment: set goals and criteria, gather evidence, monitor progress and measure achievement.

● *Individual awareness*: the individual skills needed to make the whole team work. Teams are a collection of individuals. The individual performance is assessed, as described in Part 2 in this series, but in the context of the overall group.

In summary, although the educational goal might be to improve an individual's performance in a team, we need to measure the overall team performance.

6. Options for Action

The general guidelines to implement a program to develop team skills has been given elsewhere.^[9,39] Here are some additional practical suggestions.

- See the development of an individual's skill in team work as a two-part plan: 1) develop group's skill and confidence as a team (the emphasis in this paper) and 2) develop the individual's skill and confidence as a member of a team (the emphasis in part 2 in this series). Both are needed.
- Take a single three-hour tutorial somewhere in your program and run a training workshop on interpersonal and group skills. This gives students practice using forms **2800** and **2801**. Example goals, criteria, transparencies and timing suggestions are available. ^[26,40]
- Take several three-hour tutorials somewhere in your program and run a training workshop on self-assessment. This gives students practice in applying the Principles of assessment outlined in section 2. Example goals, criteria, transparencies and timing suggestions are available. ^[26,40,41] Such training helps improve the reliability and the student's understanding and acceptance of self and peer evaluation. We feel that such training is essential if self and peer evaluation is to be used in the program.
- Expect all groups - lab groups (even if it is a team of two), project and design groups, formal cooperative learning groups and problem-based learning groups - to set goals for growth and assess performance. We have used all four forms, **2800** to **2803**, for different aspects of group work in the MPS program. ^[10] Table 3 provides guidance for the selection of the form of evidence and purpose of assessment most appropriate for your situation.
- Support your students in their efforts to improve group performance. Suggestions are available for the dozen plus issues to address in a "norms" meeting. ^[40] First-aid for different symptoms of ineffective groups have been synthesized ^[42] from Francis and Young, ^[3] Tiberius ^[43] Fisher et al., ^[44] Langford and Postans, ^[45] and Valiquet ^[46]
- To evaluate the effectiveness, to improve your program, and to provide evidence for ABET 2000, gather benchmark data and collect sample portfolios about group growth (described in Option 9). Data from Form **2800**, Table 2 and Option 2, can also provide evidence to document growth.
- Assessing the overall team work is important. Our goal is to have effective teams and not just collections of individuals. The individuals must pool their skills to create great teams. Assessing the overall team work is important because this provides the context for our ultimate goal - the development of individuals who function well in teams.

7. Summary

1. The five Principles of assessment provide a framework for developing and using instruments for assessment of student performance and of the evaluation of program effectiveness.
2. Crucial to any assessment is the creation of published goals and measurable criteria that form the context for the performance of the student. Evidence should be gathered and assessed in the context of these goals and criteria. Four example sets goals and criteria were presented.
3. Some example objectives and levels of development for team work are given to provide a context for learning and assessment.
4. Assessment is based on evidence of performance. Nine options for gathering evidence were described.
5. Practical suggestions for the development of effective teams include developing both overall team skill and skills in individuals, provide training in group skills and self assessment, expect all groups to gather

evidence each time they meet, provide support for their efforts to overcome difficulties and gather benchmarking data.

6. Our ultimate goal is to develop and assess an individual's skill in working effectively in teams.

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Table 1 Features of collections of people, groups and teams

	Collections of people; “meetings”	Effective Groups	Teams
Goals	Each has own goals; the collection may have meetings without any clear goals	Individuals may have own goals but there is general acceptance of group goals	Clear stated goals that all accept unanimously.
Roles	Each does his/her thing	May be unsure of role; may have been assigned role and does his/her best in the role.	Each is very clear about role
Decision-making	Must we make a decision?	By vote	By unanimity
Interpersonal conflict	Hope it never happens; if it does, ignore.	Have some methods for coping effectively with conflict but conflict still tends to be an unwelcome visitor.	Team has method for handling; conflict welcome because it aids in seeing things from different perspectives
Trust	In myself	Developing	High
Level of involvement	Low, prefer to be elsewhere	Moderate	High
Skills supplied to team	Tend to put on a happy face and accept whatever. Rarely let your true skills show. Personal assets are rarely known by other group members	Some unique skills are known and are used moderately by the group. The group prefers to have friends with similar styles working together.	Unique skills are used effectively by the team. Interpersonal differences are recognized as assets to the team.
Attitude	“I”	“I-we”	“We”

Table 2 Evidence-based targets for group skills (reprinted from references 4,17) Form 2800 .

Evidence-based targets	Progress toward internalizing these targets				
	20%	40%	60%	80%	100%
● Performance improves when we have goals. ^[18]					
● Assessment must be related to the goals ^[19]					
● Both Task (getting the job done) and Morale (feeling good about the group work and about how you have interacted with the other group members) are important ^[19]					
● Any group functions better with a chairperson ^[20]					
● Chairperson and leadership are different; different people may become leaders at different times. ^[20]					
● Group evolution tends to follow a pattern described as by such descriptors as “ forming, storming, norming and performing” ^[19,20] . Schutz’s instrument FIRO-B ^[12,21] seems to provide reliable insight as to the personal style of individuals towards other group members during three of these phases.					
● We can list the roles needed in both Task and Morale to make an effective group. ^[19]					
● When each person has a clear idea of roles and group norms, the group functions better. ^[19]					
● When groups are functioning effectively, about 70% of the time is spent on the task; 15% on morale building activities and 15% of task process activities (how the problem solving process is going; summarizing ideas, guiding the process). ^[22]					
● The products from groups or teams is improved when members have different “styles” (in Jungian terminology some members are dominant S, and some, dominant N). The products from groups tend to be inferior when all the members “think and behave alike”. ^[23,24, 19,20]					
● The quality of decisions, product, task is improved if group members offer different perspectives, disagree and seem to introduce conflict into the process. The trick is to manage the apparent conflict well. ^[19,23,24]					
● The characteristics of “ meetings of individuals,” “effective groups” and “teams” fall on a spectrum with sufficient differences that it is useful to differentiate based on those characteristics					
● In a decision-making mode, after 20 minutes of discussion on any one topic, few new ideas are presented and repetition of previously stated ideas occurs. ^[25]					

Table 3 Some options for the use of the assessment forms and for individual and group skill acquisition

General Goal	Details	Sources of evidence	Comment
<p>1. To improve student accountability and thereby improve student morale about what is going on in the group; To explicitly require groups to continually monitor their progress and to improve.</p>	<p>Group Self assessment: As a group, over a sequence of meetings, the task and morale ratings for the group shall increase by 1 unit (between the first and last meeting). Individuals must submit their own collection of forms including their personal input.</p>	<p>2800, 2802</p>	<p>Requires 10 minutes after each group meeting. Marking load can be reduced by having group reports at the expense of individual accountability and skill development.</p>
<p>2. To explicitly require groups to continually monitor their progress and to improve. Because a single report is expected from the group, individual accountability is missing.</p>	<p>Group Self assessment: As a group, over a sequence of meetings, the task and morale ratings for the group shall increase by 1 unit (between the first and last meeting). One summary report is handed in per group with each person getting the group mark.</p>	<p>2800, 2802</p>	
<p>3 To explicitly require groups to continually monitor their progress and to improve.</p>	<p>Group Self assessment. As a team, over a sequence of meetings, the five strengths will be maintained and one area to work on will be shifted to a strength (between the first and last meeting). This can be done requiring single team reports or with individual reporting.</p>	<p>2800, 2802</p>	
<p>4.To explicitly require groups to continually monitor their progress and to improve.</p>	<p>Group peer assessment. An assessment observer group will complete form 2800 for the team with each member listed and provide feedback about the team's and individual process. The result of this feedback will be compared with the evidence given by the group in #1 to 3. Peer assessment in addition to self assessment.</p>	<p>2800, 2801</p>	<p>Cuts the student working time on the project in half if use peer assessors.</p>
<p>5. To help students "understand" what should be happening in a group. The focus is on becoming skilled at observing group dynamics and gaining insight into self performance.</p>	<p>Use group on group individual observation in a workshop devoted to becoming familiar with form 2800 and the group process. The workshop takes between 1 and 4 hours. No direct follow up is expected. Students hand in individual reports based on the evidence each received from a personal observer.</p>	<p>2801, 2800</p>	<p>Requires workshop.</p>

Figure 1: Example options for assessing group and individuals within groups

Form A: First of 26 entries

		Names of group members				
Helpful Behaviors						
Initiates and contributes ideas Arrives on time and is prepared Completes assigned tasks Arrives with questions or comments Shares knowledge						

Form B: First of 8 entries

		Names of group members				
Task						
Observer of the task process	Orients group, monitors, summarizes, seeks direction, identifies phases in problem solving + process					
	Ignores phases, asks whatever he/she wants, blocks, unaware of his/her contributions -					

Figure 3: Rating form **2801** for external observers of individual contributions to the group (reproduced with permission from Woods [4])

Observer _____ - Client _____ Case _____

Task		Group members					
Task process observer; (problem solving process)	Orients group, monitors, summarizes, seeks direction, identifies phases +						
	Ignores phases, asks whatever wants, blocks, unaware of contributions -						
Information or Opinion Giver (related to task)	Assertively gives information, makes suggestions +						
	Withholds information, silent, aggressive, passive -						
Information or opinion Seeker (related to task)	Asks questions, checks comprehension +						
	Silent, refuses to ask questions -						
Energizer Risk taker	Enthusiastic, introduces a spark, novel ideas +						
	Follower, agrees, silent unsure -						
Morale							
Observer of interpersonal process	Sensitive to interpersonal dynamics, comments on what's going on +						
	Ignores conflict, tension, hopes it'll go away -						
Giver of praise and support	Warm, responsive, gives help, rewards +						
	Put downs, aggressive, self-centered, defensive, critical, contemptuous -						
Interpersonal problem solver: Seekers solutions	Mediates, harmonizes, helps resolve conflicts +						
	Causes problems, seeks personal goals -						
Energizer tension relief	Jokes, laughs, shows satisfaction +						
	Withdraws, causes tension -						

Strengths

Areas to work on

Figure 4. Rating form 2802 for group self assessment including an opportunity for individual reflection (reproduced with permission from Woods [26])

Form 2802

Task: Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. The accuracy in the group’s answer matched the time available. Group avoided contributing excessive information.

None of these behaviours		Few of these behaviours but major omissions		Most features demonstrated		All of these behaviours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

None of these behaviours		Few of these behaviours but major omissions		Most features demonstrated		All of these behaviours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Individual Contribution to Task and Morale

Group Strengths

Group Areas to work on

<hr/>	<hr/>
<hr/>	<hr/>
<hr/>	
<hr/>	

Figure 5 Rating form 2803 for individual assessment of teams

Assessment of your team

Name: _____

● **Teamwork:** Task all members clear about and committed to goals; all assume roles willingly; all influence the decisions; know when to disband for individual activity; all provide their unique skills; share information openly; the team is open in seeking input; frank; reflection and building on each other's information; team believe they can do the impossible; all are seen as pulling their fair share of the load.

The degree to which these descriptors describe your team's performance (as substantiated by evidence: meetings, engineering journal, interim report, presentations).

None of these behaviors		Few of these behaviors but major omissions		Most features demonstrated		All of these behaviors
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

● **Teamwork: Morale:** Trust high, written communication about any individual difficulties in meeting commitments; cohesive group; pride in membership; high *esprit de corps*; team welcomes conflict and uses methodology to resolve conflicts and disagreements; able to flexibly relieve tension; sense of pride; **we** attitude; mutual respect for the seven fundamental rights of all team members; Absence of contempt, criticism, defensiveness and withdrawal.

The degree to which these descriptors describe your team's performance (as substantiated by evidence: meetings, engineering journal, interim report, presentations).

None of these behaviors		Few of these behaviors but major omissions		Most features demonstrated		All of these behaviors
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Additional comments:

Strengths of your team

Areas to work on

<hr/>	<hr/>
<hr/>	<hr/>
<hr/>	<hr/>

from D.R. Woods (1997)

Attach any pertinent additional evidence that we should consider. Thanks.

Assessing team work. part 2: individual contributions to the team

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Abstract:

Individual contributions to team work should be assessed to keep individuals accountable and to develop individual skill. Four options are given for the goals and criteria for individual contributions. Thirteen forms of evidence are listed. Six relate to one's contribution to the technical result. Five forms give evidence about an individual's contributions to the teamwork. Two options provide evidence about skill in self-assessment.

Rationale is given for the need to assess both the technical and team aspects of team work. Examples are given of how teamwork was assessed in the McMaster Problem Solving program in both a junior level project course and in a capstone project course. Data are given to illustrate the types of evidence collected and the relationship among the evidence.

Suggestions are given about program evaluation and gathering evidence for ABET 2000 accreditation.

Keywords:

Assessment, group work, teams, goals and criteria, forms of evidence, rating forms, ABET 2000, capstone course, exit surveys, program outcomes.

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He shoots; He scores! The crowd goes wild as the home team wins. Yes, it is vital that the team performs well. In addition to the wins and losses of the team, individual records are kept for each player: the number of penalty minutes, the goals scored, the assists, the plus-minus and the goals against. Based on lousy individual performance the player will be benched, traded or sent to the minors. Individual contribution to the team can and should be measured.

In Part 1 of this series, ^[1] we differentiated between effective groups and teams, suggested methods of developing skill in group work and reviewed the elements of assessment. Then we considered options to assess the overall group or team performance. In this part 2, we consider how empowerment and accountability are linked, list goals and objectives for individual skill development in team skills, give options for forms of evidence, the merits of self and peer assessment, our results from using some of these approaches and offer ideas about how to select assessment consistent with your context. These suggestions are directly applicable to satisfying the ABET 2000 ^[2] criterion 3.d which requires that our graduates have “an ability to function on multidisciplinary teams.”

1. Why it makes sense to assess individual contributions to the team: Empowerment and individual accountability

When students are empowered to operate as autonomous groups to complete a task, then each member of the group should be accountable to the group and to the person who created the groups in the first place, namely the teacher. Being assigned to work in an autonomous group or team does not give any student the right to shirk his/her duties, to opt out of being responsible to the group, or to hide in the group.

To continue with the sport analogy, the contribution of each player to the team effort is clearly visible to the fans, owners and coach. So it is with team work; we need to make the individual contribution to the team visible.

Hence, the four major reasons why we need to measure and mark individual performance are 1) to make individuals accountable, 2) to allay the resentment and frustration that working members have when they think that others are not pulling their weight, 3) to acknowledge those who make outstanding individual efforts that may not be recognized by other group members because the others do not **see** that effort, and 4) to make team skills an individually-achievable outcome from engineering programs. Making individuals accountable creates a climate for good team work and development.

2. Goals and Criteria for Team players

Consistent with Principle 4 for assessment described in Part 1, ^[1] goals should be published to describe the target skills and attitudes of individuals who participate fully and effectively on teams. In Part 1 we listed options for setting goals for teams, for gathering evidence about team behavior and for assessing team effectiveness. Here we consider the goals for individuals in their quest for skill as a team player. Although initially we might be satisfied with a general objective ^[3] like “the ability to function on multidisciplinary teams” we have found it extremely beneficial, especially for the purposes of assessment, to elaborate on the skill. Such elaboration should be based on research findings ^[1] about the performance of effective team players. Here are some options for creating goals and criteria for individual skill in participating in teams.

- *Create a list of descriptors of the process:*

An example list could be the individual is skilled at both the process Task and Morale components of teamwork. Elaboration on these components was given in the companion section 3 of Part 1 in this series. The disadvantage of this approach is that the measurable criteria are not published.

- *Create a list of target skills and attitudes:*

An example list for team skills was given in Table 1 of Part 1^[1] of this series As with the previous approach no criteria are given.

● *Provide a structured list of goals moving from beginning to advanced:*

Alverno College^[4] identifies six levels of goals as applied to the development of an individual's skill in team work.

Level 1: Identify own interaction behaviors utilized in a group problem solving situation. (Eleven behaviors for the task activities used as criteria; observation by peers where strengths and weakness are noted; agreement between observer and client).

Level 2: Analyze behavior of others within two theoretical frameworks: task and morale components.

Level 3: Evaluate behavior of self within two theoretical frameworks for at least three different, videotaped situations. Self, peer and teacher assessment. Growth contract created.

Level 4: Demonstrate effective social interaction behavior in a variety of situations and circumstances.

Level 5: Demonstrate effective interpersonal and intergroup behaviors in cross-cultural interactions.

Level 6: Facilitate effective interpersonal and intergroup relationships in one's professional situation.

Forms of evidence and criteria are available.^[4]

● *List component skills and create sets of behavioural, unambiguous goals with measurable criteria for each:*

For example, in the McMaster Problem Solving program^[5], MPS, the five levels of development for individual skill (and the corresponding MPS units) are:

Level 1: Self awareness, self acceptance and acceptance of personal style and preferences of others (MPS 11).

Level 2: Awareness of attributes of successful groups/teams for the two theoretical frameworks of task and morale: (MPS 28); Groups can self assess, set goals for growth.

Level 3: Self awareness of own contributions to the group/team (MPS 28; 29). Individuals can state his/her contribution to the group process. One can gather evidence about his/her effectiveness in role as chairperson and set goals for growth. One understands the implications of FIRO-B for personal contribution to group evolution.

Level 4: Being an effective member of a "good group": demonstrate trust and skill in conflict resolution, problem solving, giving and receiving feedback and assertiveness (MPS 49, 26, 24, 43 and 44).

Level 5: Being an effective member of a team (MPS 53, 54, 47, 46 and 58).

Objectives, criteria and forms of evidence are published for the individual MPS units.

3. Forms of evidence: options for documenting and measuring individual contributions to the team

The Principles for the design of well-designed assessment or rating forms for individual contributions to teams were outlined in Part 1^[1] of this series.

Fourteen options and variations have been suggested. The first six options relate primarily to the technical contribution to the final result, report or product. Options seven to twelve relate primarily to the process skills of how the individual functioned in and contributed to the team. Options thirteen and fourteen address self assessment.

● **Option 1: *Quality of the team's written technical report or presentation.***

The product or project report is marked and then:

a. The same mark is given to everyone on the team "because this is a team."

b. The mark on the technical report is distributed among the team members on some basis.

Some options include:

- All get the same mark but students who do not attend the team meetings are asked by the instructor to leave the group.^[6] Those without a group produce their own reports. This provides one mechanism for the removal of a delinquent member. The conditions and consequences must be spelled out clearly at the beginning. The teacher issues a letter to the delinquent student after consultation with the group. The overall mark in the course must allow a student to pass based on the individual effort. For example, the teamwork counts 20%, the project report 80%.

- The total technical mark is allocated among the individuals. The group, the tutor, or the student leader decides the marks of individuals at the end of the project. If group mark is 62/100, and for a group of 5 members, then the total number of marks to distribute are $5 \times 62 = 310$ marks.^[7] This approach violates assessment Principle #4:^[1] there are no published goals and criteria for group work. This also violates Principle #2:^[1] no quantitative evidence is used. Indeed, the very idea of having to divide up the marks introduces competition rather than cooperation.

- The total technical mark is allocated among individuals based on group criteria. The group decides on the criteria at beginning of project and uses the criteria at the end of the project to distribute marks.^[7] This approach is wrong because the group mark is a part of the technical mark. Furthermore, the approach does not include the identification of the target skills (contrary to Principle #4) nor is the form of evidence to be used identified (violating Principle #2^[1]). Furthermore, all of the assessment is done at the end of the project. Data and evidence should be gathered throughout the project.

- The total technical mark is allocated equally among individuals unless they meet the contract conditions. At the beginning, the group contracts with each other that all will contribute the same to each task.^[7] Rarely do individuals contribute the same to the team. Some show leadership in computing; others are better at writing; others prefer to research the literature. Each brings different skills to the team. Each should contract to contribute their specialty, and **not** to do the same.

Regardless of how ingenious one becomes at allocating the marks, all these approaches are incorrect. If team work is a valued skill then there must be two separate assessments and two separate marks (not some division of the technical marks).

● Option 2: *Individual oral presentation of and defense of the technical results.*

Individual oral presentations of the technical findings could be assessed by the client, outside assessors, teachers, peers or self. The criteria could be defined to include communication skill, technical competence and ability to think on feet as one responds to questions. These refer to the individual contribution to the technical task. This is an important issue. However, these are not related to team skills.

● Option 3: *Combination of peer and self assessment of individual's technical contributions.*

A form similar to Form **2804**, given in Table 1, lists pertinent contributions to the technical results and gives measurable criteria for at least three levels of performance for each. Privately, individuals rate themselves and their peers. The results are given directly to the instructor who collates or summarizes the data. These data can be gathered periodically throughout the semester and at the end. Form **2805**, given in Table 2, can be used to self assess the professional, problem solving and communication skills brought to the project.

● Option 4: *Individual Test and Exams on Technical Knowledge, TETK.*

Exams and tests can be created to give individuals a chance to demonstrate that they understand the technical details of the project.^[7] These tests can be written or oral and given as spot-checks or formally built into the program. All students could be expected to take the test.

An option is to randomly call on one individual from each group. The individual's performance becomes the group's performance. This approach is used in cooperative learning groups to ensure that all of the individuals have learned the subject knowledge.

● Option 5: *Individual log/journal of the project: engineering log book.*

The log book is a combination of a reflective journal, daily goal setting and assessment, project planning and management, detailed documentation and record of contacts, and calculations. We have used this for several

projects. Some example criteria that could be used in assessing the document were:

Professionalism: (40%) documentation of progress, goals, degree achieved, new goals; standards maintained throughout, initiative in locating unique sources of data, trying different approaches and keeping an open mind; completeness: equations included, units given, nomenclature defined; quality of documentation: names, e-mail addresses, phone numbers, date contacted, questions asked, answers supplied and follow up planned; comments on reasonableness of approach and answers; comments about the limitations and errors; dating and initialing every page.

Problem solving: (20%) active with charts, diagrams, comments; monitoring statements about rationale, progress and process; systematic and organized; focus on accuracy and checking and double checking; flexible and variety of problem solving skills used; use of criteria for decisions.

Communication: (40%) readable and understandable, index and table of content; references well documented, organized.

The log books, or engineering daily log books, can be marked part way through the project and at the end. The criteria used to mark the log books are the same as the ones used in the self assessment form **2805**.

● Option 6: *Individual written critique of the project (a viva).*

Individuals write a personal critique of the project: what went well, how would you improve, satisfaction with results. Brown and Pendlebury^[7] call this a “viva”. This is an interesting form of evidence. However, the goal and criteria that provide the context for creating this evidence is unclear. Is the evidence to show that:

1. The students understood the technical project?
2. The students could assess the team activity?
3. The students could develop skill in self-assessment?

● Option 7: *Peer and/or self assessment of “role” played in team meeting.*

Individual roles (such as chairperson, reporter, researcher, checker, skeptic and computer specialist) can be assigned by the teacher or by the group. The roles can rotate or remain fixed throughout the project. Goals and criteria for each role should be defined at the beginning. Evidence/feedback about how effectively each played the role should be gathered from each meeting. For each role, there is reporting and inter-role reporting and responsibility that should be included at the end of each meeting. In other words, “*I was unable to play my role very well because others refused to get information to me on time.*”

Example data for “chairperson,” objectives, criteria, forms of evidence and self assessment of the evidence are available.^[5,6]

● Option 8: *Test and Exams in Process Skills, TEPS.*

Based on the goals given in Part 2, create examinations that test the achievement of the published objectives for team skills. Some example questions are given in Resources Chapter D^[6] and in Table 3.

● Option 9: *Self assessment of achievement of target skills for team players.*

Form **2800** given in Table 2^[1] in Part 1 lists the target for group skills. As described in Part 1 of this series^[1] the form was completed for the team as a whole. For individual assessment the form can be completed by individuals periodically throughout the semester.

● Option 10: *Combination of peer and self assessment of individual contributions to the team process.*

A form similar to Form 2804, given in Table 2, lists pertinent contributions to the team work and gives measurable criteria for at least three levels of performance for each.

● Option 11: *Reflective assessment journals about individual contributions to team work.*

The goals and criteria for individual contributions to the team are created, as suggested in section 2. Individuals gather evidence about his/her own contributions to the team: reflections, peer feedback, agendas, documents brought to the group for a task. Individuals gather evidence from the reflections after each group meeting, add reflections about what they personally did to help the team grow and assess the degree to which he/she has achieved the objectives. Examples are available.^[8]

● Option 12: *Portfolio about individual contributions to team work.*

A portfolio is a collection of evidence of “best” work. Mourtos,^[9] for example, asks students to include assignments, tests, enrichment activities and an overall reflection about the learning. Whereas Option 11, reflective assessment journals, is structured around faculty-generated goals for team work and assessment, the portfolio tends to allow students to select materials that represent their best work. Ideally the Portfolio should have a clear summary by the student of the skills they have achieved as demonstrated by the materials included in the portfolio. Mourtos recommends the development of extensive marking criteria and provides a general format for the portfolio. He found that markers spent 30 to 45 minutes marking each portfolio. We would add that the marking criteria should be published and given to the students at the beginning of the semester.

● Option 13: *Feedback or self reflection about the assessment process.*

As individuals maturing and move toward being an effective team player, each gains skill in self awareness, self acceptance and self assessment. The form in Table 4 can be used to provide evidence about skills in self assessment and in assessment.^[9] This reminds us of the Principles of Assessment outlined in Section 3 of Part 1.^[1]

● Option 14: *Feedback about the assessment process via a personal interview.*

Individuals submit a summary of the evidence and their assessment of their performance. Teachers then use this as a basis for privately reviewing the performance with each student.^[5] This provides excellent feedback about the self assessment process and prepares the student for future performance reviews in industry.

4. Team skills and Technical Answers

In Section 2 of both Parts 1 and 2 of this series, we described the goals for *generic* skill in working in teams. These apply to any professional in any profession and to any one. The *generic* skills need to be applied successfully in tackling tasks in subject domains. Engineers should use generic skills in teamwork when working on engineering problems so as to produce a superb technical answer. An outstanding team can produce a lousy answer if the team members do not have an excellent grasp of the fundamentals and practical considerations of engineering. Similarly, an excellent engineering solution could come from a lousy group.

We should gather evidence about the team’s overall performance and the team’s answer to the problem (as outlined in Part 1^[1]) as well as the evidence about the individual’s technical contribution and his/her contribution to the teamwork. For the individual contribution, Options 2 to 6 can be used as evidence about the former; options 7 to 11, for the latter. Since self assessment provides evidence, we recommend that the assessment process be assessed as well. Options 12 and 13 describe methods to determine the student’s skill in self assessment.

5. Example Assessment of Teams and Team work.

We have applied these principles of assessment and selected options in two project courses. Before both projects, the

students had workshops on interpersonal skills, group process, conflict resolution, problem solving and communication.^[5] In these workshops the students used forms **2800** to **2802** extensively. These were described as options 2 to 4 in Part 1.^[1]

A. Junior level project with a local company.

The task was given by the instructor who coordinated the activity with the client company. The students self selected their groups of two to four. The project lasted for four weeks. We encouraged students to use form **2802** after each group meeting. We required them to complete form **2804**, described in Options 3 and 10, part way through the project and at the end of the project. Data from Options 3 and 10 were gathered to improve individual accountability and were not used in determining the final mark. This worked well. Groups that initially were underperforming improved dramatically. Details of this approach, given in a slightly different context, are described elsewhere.^[10] We used Option 8 (TEPS) to assess individual skill in team work. This contributed between 10 and 20% of the final mark.

B. Senior level capstone project with a local company.

In prerequisite courses that are part of the MPS program,^[5] TEPS (Option 8) were used to assess individual skill in team work; chairperson skills (Option 7) were assessed using reflective journals (Option 11) and TEPS. Options 12 and 13 were used.

In this course for 15 to 20 students, a client company posed ten tasks. Students selected one of the tasks and who they wanted as team members. The company supplied a contact person for each project. Extensive interaction, plant visits and onsite data collection occurred. The classroom contact hours allotted to the project was 40 hours available for student-run team meetings, communicating with the company contact and visiting the site.

The technical aspects of the team project were assessed based on the executive summary and written project report from each team. Individual contributions to the team were assessed based on:

- form **2804** that was used part way through the project and at the end of the project (Option 3);
- the individual oral presentations to the client company that were assessed by the client (Option 2);
- the engineering log book (Option 5) that was independently marked by two assessors;
- form **2805**, the self assessment of the skills reflected in the log book (Option 3).

The team and individual contributions to the team work were assessed based on:

- form **2804** that was used part way through the project and at the end of the project (Option 10);
- form **2803** that was used at the end of the project (Option 5, described in Part 1 of this series).

In our context, the team skills were assessed primarily in prerequisite courses, and we used the evidence primarily for individual accountability and monitoring. Hence, for this capstone course, the mark allocation focused only on the technical contributions. The mark breakdown was:

- 10% team mark for the interim progress report;
- 30 % for the individual daily engineering log book marked independently by two markers based on the criteria outlined in form **2805**: professionalism, problem solving and communication;
- 10% team mark for technical content of report as marked by the company based on a team presentation at the company;
- 10% individual mark on presentation skill as marked by the company based on the presentation at the company;
- 40 % team mark for technical content as independently marked by two markers.

The *final grades* ranged from 51 to 97% with the arithmetic average of 86.7 and a standard deviation of 10.1.

If the team skills and individual contribution to the team are not assessed in other courses, then an illustrative allocation of marks might be 50% marks for teamwork and 50% for technical:

- 50% of the above marks for “technical contribution;”
- 50% for team work with a possible breakdown as follows:
 - 5% individual assessment based on TEPS (Option 8);
 - 5% individual assessment of rotating chairperson activities with individual reports (Option 7);
 - 5% self assessment of acquisition of target skills, form **2800** (Option 9);
 - 5% team mark of a team report on the quality of and growth of team based on a series of forms **2802**, (Option 4, part 1) together with the average of individual self-assessments of the team, form **2803**;
 - 10% self assessment of individual contributions, form **2804**, Option 10;
 - 10% average of the peer assessment of individual contributions, form **2804**, Option 10;
 - 10% individual reflective journal about individual contributions to team work, Option 11.

Since self and peer assessment are significant forms of evidence, we suggest that Option 13, a personal interview about the performance on the team, be included.

This suggested allocation of marks follows assessment Principle 5: many different forms of evidence are used.

6. Elaboration on the use of Forms of Evidence for Teams and Team skills

Example data are given for self and peer assessment of individual contributions using form **2804**. We illustrate how self and peer assessments relate to the overall *final grade* and to each other.

A. Example data for Form **2804**.

Form **2804** lists a set of desired behaviours and criteria. Each student rates him/herself and all of the other members. The rating forms were given directly to the teacher and not seen by anyone else.

Table 5 is an example of the results for Maria’s group. First, the students rated themselves as a group 8.3 out of 10. The arithmetic average of the scores for all elements on the form are given in the body of the table with the self-rating given in bold. Thus, Maria rated herself highly at 9.5 yet her overall average rating for all members of the group was 8.22. Maria was rated highly by the other members with all ranking her as first. I have added the ranking to each entry. That is, Brad rated Marie as 9.2/10, Jason 6.9/10, Suzelle 7.6/10, Margarite 6.2/10 and assigned the same average score for himself. Based on these ratings by Brad, Marie is ranked first; Suzelle, second and so on. These are typical results from a “fair” group.

These results were obtained early in the semester. Once everyone realized that this form was some measure of accountability, this group started to communicate with each other and their performance improved. This table is representative of the results from the seven other autonomous groups. This particular self and peer rating form worked well in that:

- The scores are relatively consistent. In this example, except for Margarite, the self rankings were consistent with the peer rankings.
- Just the fact that such rating forms were completed and the results seen by the teacher meant an improvement in individual accountability. Individuals could not get away with poor performance without receiving low ratings from their peers. The diligent workers feel satisfied that their dissatisfaction with their peer’s performance is reflected through their ratings that, in turn, are seen by the teacher.

B. Relating Self assessment and the Final Grade.

Data from self assessment from form **2804** correlates well with the final grade $R^2 = 0.922$. Data from the peer assessment from form **2804** correlates well with the individual final grade $R^2 = 0.924$.

C. Relating self and peer assessment from Form **2804**.

The self and peer assessments correlate with a correlation coefficient of $R^2 = 0.972$. A paired t-test indicates that the

self and peer assessments show no significant difference ($p < 0.009$).

D. Teacher's marks for log books and the student's self assessment, Form 2805.

Students complete the engineering log book and independently self assess their skills based on the same criteria used to assess the log book. The correlation coefficient between the marks by two instructors of the log books and the self assessment of their skills is $R^2 = 0.47$.

E. Student assessment of overall team effectiveness.

The students assess the quality of the teamwork in two independent inventories: one question on Form **2804** and form **2803**. The inventories were used on two different occasions. The correlation coefficient between the two ratings is $R^2 = 0.923$.

F. Individual growth from junior to senior year team activities.

A sample of students ($N = 12$) worked in teams in the junior year and then functioned in different teams in a different course in the senior year. A paired t-test showed statistically significant improvement in the individual average of peer and self ratings from the junior to the senior year ($p < 0.0042$).

G. High performing teams.

For those teams that rate themselves highly (on either of the instruments discussed in Section E), the average standard deviation of the ratings from self and peers for individual performance is smaller than it is for self and peer ratings of students in poorly functioning teams. For example, the average standard deviation of the scores for individual performance was 2.0 for a team rated as 2 out of 10; the standard deviation for individual performance was 0.24 for a team rated as 9.3 out of 10. The correlation coefficient between the team rating and the average standard deviation of individual performance ratings was $R^2 = -0.87$.

7. ABET 2000: assessment and program evaluation

ABET 2000 has given praiseworthy leadership in requiring us to do what we should be doing all along to provide ongoing evaluation of our programs. Individual Departments can set goals, establish criteria, gather evidence and make claims. This ongoing Total Quality Management approach is a great step forward in our approach to education. Following the guidelines from this paper can make it easier to satisfy criterion 3d, the creation of graduates with "an ability to function on multidisciplinary teams" and to continually improve our efforts.

The evidence can include

the evidence used to assess the students for their skill (or to give students individual "marks" on teamwork):

- the assessment evidence used by students and by teachers to demonstrate achievement of the clearly stated goals;
- portfolios or reflective journals/reports produced by students to support claims of achievement;
- results of TEPS.

the evidence of a long range, scholarly plan to develop the skills:

- documentation of the goals, criteria and Departmental plans (described in Section 2);
- example TEPS and the marking criteria;
- analyses of data gathered from forms **2804** and **2803**.

the evidence of the impact and comparison with benchmarks measured internally and externally:

- an exit survey: Queen's University^[11] has developed an excellent exit survey questionnaire. The key question is

“Please indicate the degree to which your education at Queen’s contributed to your learning and development in each of the following areas: The rating is 1 = very little; 5 = a great deal.

1. ability to work well with others”

Data for engineering from 1994 are available as benchmark data.^[11] For the MPS program, the results of the exit survey were 4.72 with a standard deviation of 0.46. Some benchmark data from other programs are 4.14 [0.69], 4.53 [0.96]^[12] and 4.14.^[11]

8. Summary

1. Individual performance in a team should be assessed. This holds individuals accountable, minimizes resentment, allows individual’s efforts to be identified and helps build skill in teamwork.
2. Any assessment requires published goals and measurable criteria. Four options are given that vary in their degree of explicitness.
3. A commonly misused form of evidence is an allocation among team members of the team mark for the technical project. At least two assessments and marks should be given: the quality of technical project and the quality of the team work.
4. Five forms of evidence are listed of the individual’s performance of the technical subject aspects (chemical engineering).
5. Five forms of evidence are given of the individual’s contribution to the team work.
6. Because written self assessment is such a valuable form of evidence, two options are given to assess skill in self assessment.
7. A description is given of how team skills were assessed in a junior level project: forms of evidence selected and the contribution toward the final mark.
8. Details are presented of how team skills were and could be assessed in a senior capstone project course.
9. Exit surveys provide useful evidence of the effectiveness of programs to develop team skills. Our graduands rated our program as contributing 4.72 out of 5 in the development of the ability to work with others. Other benchmark data show values of 4.14, 4.14 and 4.53.
10. Suggestions are given about various data that can be used for overall program evaluation, such as the ABET 2000 evaluation.

9. Acknowledgments

We thank three colleagues from McMaster University Professors C.M. Crowe and A.N. Hrymak, both from Chemical Engineering, and Professor R.C. Hudspeth, Engineering and Society Program, for their assistance in writing this paper.

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Table 1 Form 2804, Self and peer assessment of contributions to team work (developed by C.M. Crowe and used with his permission)

Name

<p>Assessment of the group</p> <p>(10) Group worked well together, making the project more interesting. (5) Group usually worked well together, with occasional difficulties (0) Group could not work together at all, making the project more difficult</p>	
---	--

Please enter a mark from 0 (worst) to 10 (best) in each row, for yourself and the other members of your team or group. If you cannot make an assessment, enter U for Unable to Observe. Your assessment should be about performance and should be based on evidence you have seen or heard.

<i>Enter your initials in the first cell to the right and those of the other members of your group in the remaining cells</i>	self					
<p>Leadership</p> <p>(10) Provided direction, inspired the others (5) Willing follower, took direction easily (0) Frustrated the group, blocked progress, criticized the others</p>						
<p>Cooperation</p> <p>(10) Worked readily with the others, contributed to the group work (5) Cooperated with occasional prompting (0) Rarely contributed, worked mostly alone, had to be coerced into cooperating or would not cooperate.</p>						
<p>Initiative</p> <p>(10) Produced good ideas which helped others, solved problems (5) Accepted other's ideas and improved on them (0) Criticized other's ideas, never contributed his/her own ideas'</p>						
<p>Attitude</p> <p>(10) Positive, encouraging the others to work better (5) Neutral, worked well with the group without enthusiasm or grumbling (0) Negative, complained about the project, worked unwillingly with the group</p>						
<p>Computation</p> <p>(10) Helped others to understand and use computer tools better (5) Good but not innovative in using the computer tools (0) Uninterested or unable to use computer tools effectively; needed constant help to become useful at computing</p>						
<p>Effort</p> <p>(10) Worked very hard on tasks assigned by the group or on his/her own (5) Worked reasonably hard, given other courses and commitments (0) Did not work much at all, tasks were either not done or were unsatisfactory</p>						

<i>Enter your initials in the first cell to the right and those of the other members of your group in the remaining cells</i>	self					
Research (10) Found many additional published papers, contacts or internet sites which greatly helped the project (5) Read only the assigned material and used that knowledge effectively (0) Had not read any material about the project, relied on others for information						
Communication and written reports (10) Organized and wrote major parts of the report (5) Contributed his/her share of the writing of the report (0) Made little or no contribution to writing of reports.						
Individual assignments (10) Did all of them on his/her own, helped others (5) Did most of them, perhaps with some help from others (0) Either did few of them or most of them handed in were copied.						
Pertinent technical/subject Knowledge (10) Excellent grasp of the technical fundamentals for this project and shared and used this effectively (5) Reasonable understanding of the basics and used this effectively (0) Little or superficial understanding, relied on others						

Table 2. Form 2805, Self assessment of engineering day books for professionalism, problem solving and communication.

Self-assessment

Name: _____

● **Professionalism:** set goals, monitor weekly progress and document, maintain consistent standards of performance each week throughout the project; show initiative; keep an open mind; calculations and work are complete and correct (equations given, units specified, nomenclature defined), comments about reasonableness of answers, about the assumptions, and about the limitations, errors included; date and initial each page.

The degree to which these descriptors describe your performance (as substantiated by evidence: meetings, engineering journal, interim report, presentations).

None of these behaviors	Few of these behaviors but major omissions			Most features demonstrated	All of these behaviors		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7	

● **Problem solving:** **Active:** make checklists, charts, lists, diagrams; **Monitor:** ask why? identify purpose and interpretation of the PS process you are using; **Systematic and organized:** **Focus on accuracy:** check and double check; use many different methods; **Flexible and keep options open:** Use a variety of PS tactics and skills; **brainstorm,** use explicit criteria **Define:** focus on defining the problem instead of activity with unknown purpose; willing to spend at least 1/2 the time to ensure that you are working on the right problems.

The degree to which these descriptors describe your performance (as substantiated by evidence: meetings, engineering journal, interim report, presentations).

None of these behaviors	Few of these behaviors but major omissions			Most features demonstrated	All of these behaviors		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7	

● **Communication:** **Audience:** address and answer client's questions at client's level of understanding; **Content:** include factual evidence to substantiate claims; include units, assumptions, clearly explain limitations of your work; complete references for the source of data; **Organization:** systematic, well-organized with appropriate advanced organizers, transitions and summaries; no faulty subordination or coordination, index or table of contents included in engineering day-book; **Style:** understandable, coherent, readable, interesting, succinct; **Format:** grammar, spelling, punctuation correct; appropriate format used for all communications.

The degree to which these descriptors describe your performance (as substantiated by evidence: meetings, engineering journal, interim report, presentations).

None of these behaviors	Few of these behaviors but major omissions			Most features demonstrated	All of these behaviors		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7	

Strengths

Areas to work on

from D.R. Woods (1997) A87

Attach any pertinent additional evidence that we should consider. Thanks.

Table 3 Sample questions based on objectives for component skills for team work, TEPS

1. (20 min) **Meetings** The following is the first part of a design meeting with Charles (age 35, head process engineer), Jack (age 55, engineer), Jane (age 23, engineer in training), Josephine (age 30, process control engineer) and You, a summer student.

- a) Comment on the group skills that each person is using; use the Group feedback form in Figure 2 as a guide.
- b) List five strengths and two areas to work on for Charles and for Jack.
- c) Comment on the process they are using in this meeting.
- d) What would you say now?

Charles (chair) OK, I circulated the agenda. Our task is to select a pump for the MS plant. I trust that all have brought the company design manual and that we are ready to proceed. I suggest that we spend the first 20 min. ensuring that we have defined the correct problem. Then, we work on sizing and selecting the pump for the next 30 min.

Jane Sounds good. But shouldn't we wait for Jack. He is supposed to be at this meeting. He always has good ideas.

Charles He knows about the meeting. I like to start on time. Alright, we have to move 20 L/s of butane from the storage tank on the ground level up 15 m to the feed tank. Seems pretty straight forward.

Jane I still think we should wait for Jack.

Charles He may show up in 1/2 an hour. What do we do in the meantime? We all have busy schedules. Do you want to do this job or just wait for Jack? Jack's OK but let's just get started.

Jane (reluctantly) Ok let's get started... On this problem since this is a liquid, I think we use 1 m/s, size the pipe and estimate the friction loss. Oh, we should consider the process control because we have a controller in the system and we need to allow a large pressure drop, about 40 kPa is what I would suggest. Take that info and plug it into Bernoulli and we've got our pump. Josephine, you can help with the process control system.

Jack (Meandering in with his coffee cup and a smug look on his face). Morning all. Didn't get your agenda, Charlie, until this morning. You need to get those agendas out earlier old boy. I have so much stuff to do. I need to plan carefully and giving me agendas at the last minute is the pits.

Charles Good afternoon! The name is Charles. The agendas were delivered personally to your office one week ago. Don't give me that *#! Jane, shall we continue.

Jane I think we should define the real problem. Let's hear what the summer student, whose had all that stuff just last semester, thinks about that... (and Jane turns to you for your response...)

You Write out your response

*****end of question 1 *****

Time 7. You have been asked to chair a 50 min "design meeting" to introduce your colleagues
13 min to the short cut design procedures for fluidized beds. (Given in Chapter 3 of the book
min "Selecting Process Equipment"). The five engineers have agreed that the meeting will be held on
December 30, 1993.

- a) Create the agenda.
- b) List three actions, relative to this meeting, you personally would take between now and the meeting.
- c) Estimate the time required for each of the actions listed in part b).

***** end of question 7 *****

Time 8. Chairperson

20 min Your company has decided to explore the possibility of using a fluidized bed reactor for the production of 1000 Mg/d Phthalic anhydride. You have been assigned the role of Chairperson for the "Quickie design Meeting." You are familiar with PDEP and realize that you can probably do a quickie sizing of the reactor and a costing to test the waters. The meeting is to last 2 h and is 1 week from today.

- a. Create an agenda for the meeting.
- b. List any activities you would do between now and then and rationalize.

***** end of Question 8 *****

Time 5. Self awareness and understanding of inventories about personal style You are on a team consisting of the people listed in Table 2. Also listed are the Jungian typology and Kirton inventory and for the **other** people. Add your own scores.

20 min What are the implications of these results of these inventories on

- (a) Potential conflict: be concrete and identify the people, their behaviour and explain the conflict and the "degree of conflict".
- (b) Team "blind spots" where the team may not be as effective.

Table 2: Your team (for question 5)

Member	I	S	T	P	KAI
YOU					
Andy	23	25	15	19	85
Lisanne	15	28	13	20	91
Jean	28	21	26	13	82
Tom	10	30	35	26	70

*****end of question 5 *****

Table 4 Feedback about assessment

Goals: Content is well identified, goals are challenging and achievable, goals are written in observable terms, goals are unambiguous, the "given" conditions are specified.

None of these behaviours	Few of these behaviours but major omissions		Most features demonstrated		All of these behaviours	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Criteria: Criteria are consistent with the goals and are measurable and practical. The criteria are challenging and achievable.

None of these behaviours	Few of these behaviours but major omissions		Most features demonstrated		All of these behaviours	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Evidence: The type and quality of evidence gathered is consistent with the goals and criteria. The evidence has been gathered conscientiously over a long enough period of time. The evidence is well organized. The quality and extent of evidence is sufficient to allow me to judge the extent to which the goals have been achieved.

None of these behaviours	Few of these behaviours but major omissions		Most features demonstrated		All of these behaviours	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Process: The assessment process has been applied and as an independent assessor I concur with the decision as to the degree to which the goals have been achieved.

None of these behaviours	Few of these behaviours but major omissions		Most features demonstrated		All of these behaviours	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7

Strengths

Areas to work on

_____	_____
_____	_____
_____	_____
_____	_____

from D.R. Woods, "How to Gain the Most from Problem-based Learning" (1994)

Table 5: Example results from form 2804

Group rating: 8.3 (8.3)	As seen by					Score for individual and standard deviation
	Maria	Jason	Suzelle	Brad	Margarite	
Maria	9.5 1	8.95 1	9.1 1	9.2 1	8.6 1	9.07 [0.33]
Jason	8.5 2	8.55 3	7.9 4	6.9 3	7.2 4	7.81 [0.75]
Suzelle	8.4 3	8.95 1	8.7 2	7.6 2	7.8 3	8.28 [0.59]
Brad	6.8 5	7.43 4	7.6 5	6.2 4	4.9 5	6.6 [1.1]
Margarite	7.9 4	7.43 4	8 3	6.2 4	8.3 2	7.57 [0.82]
Rating scale used by individual.	8.22 [0.98]	8.26 [0.78]	8.26 [0.62]	7.22 [1.25]	7.36 [1.47]	average of rating standard deviations 1.02

Assessing student performance in problem-based learning

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Abstract:

Five principles of assessment are outlined. The importance of published goals, measurable criteria, multiple sampling and various forms of evidence is emphasized. Examples and suggestions are given as to how these might be handled effectively in the context of small group, self directed, self assessed problem-based learning. Examples are given in health sciences, engineering and business.

Keywords:

Assessment, lifelong learning, objectives, goals and criteria, forms of evidence, rating forms, problem-based learning, McMaster Problem Solving program.

Problem-based learning embodies most of the principles suggested by Chickering and Gamson to improve student learning^[1]. Overall evaluations to prove that PBL is effective, by comparison groups, are still tentative^[2]. Graduates of PBL program display different behaviours, especially they take more time with patients^[3]. Studies in Physics have shown that, compared with traditional lecture-based courses, students in active-learning^[4] and in PBL environments^[5] show improved pre-post gains based on the Force Concepts Inventory^[6,7] (gains of 0.23 for lecture; 0.48 for active and 0.45 - 0.65 for PBL). PBL environments develop deep learning instead of surface or rote learning^[8,9,10], provide improved learning environment as measured by the Course Perceptions Questionnaire^[9, 11, 12, 13], provide a professional context for learning new knowledge^[14], develop lifelong learning skills^[9,11] and develop student's self confidence^[9,15]. Exit surveys, using Queen's University Exit survey^[16], has shown that graduates from our PBL program self rate their acquisition of problem solving, critical judgement and team work higher than graduates from a traditional program.

In PBL students learn subject knowledge and concurrently are given the opportunity to develop skills in lifelong learning, problem solving, group work, communication, self assessment, change management and critical thinking. We refer to the latter skills as "process skills". Yet, if we are using small group, self directed, self-assessed problem based learning, some common concerns include how do we assess the student's performance relative to the quality of the knowledge acquired and the process skills developed?

Graham Gibbs^[17] says "Whoever owns the assessment, owns the learning". The impact of assessment on learning has been reported elsewhere^[18, 19]. Savin-Baden^[20] reminds us that "Assessment is an area that is often problematic on programmes which espouse self-direction and learner-centred approaches because of issues of power and control between tutors and students..... For example, the form of assessment can encourage students to adopt methods of learning that ensure they pass the course with high grades, rather than adopt learning approaches that would be in their best interests as an individual and a group member." Many have addressed the issue of assessment in the context of PBL^[21-26]. Here we will do our best to summarize the various approaches and share our experience. We have developed and used a variety of assessment methods in our PBL program that started in 1982.

In this paper, we review the principles of assessment, describe how the context is established for assessment and list goals and criteria and suggest options for gathering evidence. Examples are given of the assessment methods we used. This is described in the context of assessing student performance in the context of PBL.

1: Principles of Assessment

We define assessment as "a judgment based on the degree to which goals have been achieved using measurable criteria and pertinent evidence." Five principles embedded in this definition include:^[27-30]

Principle 1: Assessment is a judgment based on performance - not personalities. We need to help a student realize that a poor mark does not mean he/she is a bad person. The judgment is made

about performance in completing a task. It has nothing to do with his/her value as an individual. This is an issue, especially for students with attitudes characterized by Perry's level 2, who believe *that a bad mark means he/she is a bad person*. More details about Perry's levels and their implications to teaching and learning are given elsewhere. ^[27, 31, 32]

Principle 2: Assessment is a judgment based on evidence - not feelings. We might intuitively feel that a student is skilled at team work. However, we need to replace that intuitive feeling with physical written evidence.

Principle 3: Assessment should be done for a purpose with clearly-defined performance conditions.

Principle 4: Assessment is a judgment done in the context of published goals, measurable criteria and pertinent, agreed-upon forms of evidence. That is, all involved in the assessment process have received a written copy of the goals, the criteria and the forms of evidence. In conventional programs this is usually supplied by the teacher. In PBL, the students create the goals, criteria and forms of evidence.

Principle 5: Assessment should be based on multidimensional evidence: static and dynamic situations; small assignments and lengthy projects; academic, social and personal contexts; under a variety of performance conditions (exams and homework, written and oral, performance as an individual and as a member of a group); using formative and summative data and with different persons being the assessors (self, peer, teacher and trained external observers)^[33].

To remove ambiguity from the assessment, the following six *issues in practice* should be addressed.^[27, 29, 30]

1. Goals: What is being assessed? Knowledge in chemical engineering? Skills? Attitudes? Have the goals been expressed unambiguously in observable terms? Who creates the goals? Are the goals explicit and published?
2. Criteria: Do the criteria relate to the goals? Can each criterion be measured? Who creates the criteria? Are the criteria explicit and published?
3. Form of evidence: Is evidence consistent with the criteria? Do both the assessor and the student know that this form of evidence is acceptable?
4. Resources: Are the goals and the collection of the evidence possible to achieve in the time provided and with the resources available?
5. Assessment process: What is the purpose of the assessment? Under what conditions is the student's performance assessed? Who assesses? What type of feedback is given by the assessor? (For example, Pass/ fail? A grade? A list of the five strengths and two areas to work on?) What is the form of feedback? Verbal? Written? What is the timing of feedback? Who delivers the feedback?
6. Training in the assessment process: Have both the student and the assessor received training in assessment?

Failures of assessments to accomplish their purpose can usually be traced to violations of any one of these five principles or to the incorrect application of the six issues in practice. Doing an

assessment well is not easy. For example, we reviewed 26 refereed papers describing the assessment of team work that were published in notable education journals between 1999 and 2001¹. The assessment process (and hence the results) was invalid in all of the papers. Several mistakes were made. In none of the work were observable, unambiguous goals presented, indeed no goals (other than “good teamwork” whatever that means) were given in 20 papers. The goals given in 6 papers were ambiguous. Measurable criteria related to the goals were not published in any of the papers. Ambiguous or criteria unrelated to the goals were given in 3 papers. No criteria were published for 23 papers.

As another example, we reviewed the assessment process used in a residency program¹. The goals and outcomes were published, but were expressed in ambiguous and unobservable terms. The rating form was poorly designed, considered only about half of the stated goals and included goals that were not listed as goals.

On a positive note, our evaluation of an assessment process used in another program showed published, unambiguous goals with consistent measurable criteria. They published the details of one major form of evidence¹. Yes, assessment can be applied successfully.

2. Setting the context

For student performance, whether assessed by faculty, peers, external evaluators or self, the context must be clear. From principle 4, the context is published goals, measurable criteria and pertinent and agreed-upon forms of evidence. We will first consider goals and criteria, and then the elements in the assessment process are discussed.

2.1 Published goals and criteria

The goals apply to the discipline-specific knowledge and process skills.

2.1-1 For discipline-specific knowledge and skills

For a traditional lecture-based course, learning objectives that satisfy accreditation requirements are created by the faculty and given to the students through the syllabus and throughout the course. Contrast this with a PBL course. For each session faculty start with learning objectives and educational goals (similar to the ones they created for a traditional course) but now the faculty use these objectives as the basis for crafting professionally significant problems/cases. Other criteria for crafting PBL problems are listed elsewhere^[34-36]. In PBL the key is that the problem must be cued and so crafted that the students, by engaging with the problem, will generate, as a minimum, the *same* learning objectives as the faculty used in creating the case. The difference is that the students now feel ownership of the learning. Gaining this degree of

¹ Details are available from the authors.

agreement between learning goals used by faculty to create the cases and student-generated learning goals is not a trivial task.

In groups where a tutor is present, the trained tutor guides the process until the target learning goals have been identified and prioritized. In this way, the tutor ensures that the student-generated learning objectives are consistent with the program and accreditation goals.

In tutorless groups^[37], Dolmans et al.^[38] report that these groups usually can identify about 60% of the target learning objectives. In our 25 years of experience with PBL and tutorless groups, we provide explicit training^[39, 40] in goal identification. Furthermore, the goals meeting consists of two parts: identifying and prioritizing the learning goals and secondly, contracting and allocating resources. Before any group tackles the latter, the list of student-generated goals must be validated by the tutor. An example validation form is given in Table 1. A tutor and teaching assistant can handle about a dozen autonomous groups. In our experience, trained autonomous groups can usually identify about 90% of the target learning objectives.

The criterion is usually “that the learning objectives shall agree within 95% of those identified by the tutor”. At first glance, this might appear to violate one of the tenants of PBL - namely empowering the students with the task of identifying their learning needs. However, PBL is not giving student license to study whatever they want. Rather, the responsibility is on the instructor to craft the problem so that the students identify learning objectives consistent with the course (and accreditation) expectations. If the student’s learning objectives do not agree with the instructor’s learning objectives, then the problem has been poorly crafted.

2.1-2 For the process skills

Our experience has been that it is wise to publish the goals and criteria for the process skills (instead of asking students to generate them). These should be based on research evidence and not on intuition^[9, 39, 41]. An example of the evidence we have found related to lifelong learning skills is given in Table 2^[42-49]. This evidence can then be converted into learning objectives and criteria, as illustrated in Table 3.

Goals and criteria have been published for other process skills such as problem solving, critical thinking, learning, personal awareness-acceptance, self assessment, time and stress management, change management, group skills, chairperson skills and conflict resolution^[9, 39, 41].

Some discussion has occurred in the literature as to whether process skills exist separate from a context. For example, Norman suggests that problem solving skills are not independent of knowledge^[23]. On the other hand, Stewart^[50] says “...all problem solving is based on two types of knowledge: knowledge of problem-solving strategies and conceptual knowledge.” We see this as a semantic issue. First one needs to distinguish between exercise solving and problem solving^[27, 39, 49, 51 - 54]. In exercise solving one recalls and uses solved examples from past experience, examples of how the person solved similar situations in the past. Experienced professionals rarely use problem solving; they are exercise solving because they have had so much professional experience^[26, 55]. Problem solving occurs when one doesn’t have any previous past solutions to problems similar to the one being addressed. When discussing problem solving, our stance is that there are elements of the problem solving process that skilled problem

solvers display that are independent of the knowledge, and these can be made observable and measurable. These include being active, focusing on accuracy, monitoring the process, and maintaining a set of about a dozen hypotheses in clinical situations or trouble shooting problems [27, 49, 56-58]. An elaboration of such problem solving skills and options and evidence for assessing problem solving skills is available [57,58].

For the learning goals, there must be measurable criteria.

2.2 The assessment process

Four issues important to the assessment process include who does the assessment, the astute design of the forms of evidence, what training is provided to the assessors and addressing the issue of ownership of the process.

2.2-1 Who does the assessment

With tutored groups, some use assessment by the tutor. This is challenging because Swanson et al. [8] and de Stephen [59] report that it is difficult for one person to provide assessment of more than two people at the time. Since tutorial groups usually range in size from 5 to 11 members, placing much emphasis on tutor assessment is questionable. Peer and self assessment are probably more reliable forms of evidence. For large classes (one faculty member with 10 to 100 students) one can use tutorless groups. Our experience with tutorless groups [60] has been that peer and self assessment has been a reliable form of evidence. For example, the difference between final written exam mark and the self assessment mark was -0.8 % with a standard deviation of 5.84 for n = 265 students.

2.2-2 The design of the forms of evidence

The form of evidence must be well-designed.

For written examinations, the tasks must be consistent with the published goals and criteria, questions clearly stated, reasonable in expectation [61,62], appropriate in intellectual expectation (using Bloom's taxonomy or SOLO) [63, 64, 28], with the appropriate complexity [65] and degree of explicitness [66].

For written multiple choice questions, MCQ, Case and Swanson offer suggestions [67].

Consider rating forms. Whether the assessor is observing or self assessing the performance of knowledge or skills, often a rating form or scoring rubric is devised to attempt to provide criterion-based assessment.

The rating form should be valid and reliable. The items included in the form must be consistent with the criteria. The rating form should not contain more items than are convenient for a rater to consider at any one time, and the form must be related to the goals and criteria which are described in some detail on the form.

An observer assessing a group should not be expected to rate more than two or three people at one time ^[24, 59] and the form should be organized in convenient chunks around the main elements of the process being observed. Compare, for example, the two forms in Figure 1 that have been used to assess an individual's performance in a group. Form A shows only the first entry of 26 items; Form B shows the first of 8 items. First of all, expecting an observer to keep track of and rate 26 different items is asking for super-observers. We think, in form B, that an observer has a chance to remember and rate only 8 items. Secondly, Form A places these in the category of "helpful behaviors". Research suggests that Task and Morale are the two major issues to consider in group work. These descriptors in Form A sound like task issues but "arriving on time and prepared" can be construed as a Morale issue. Such ambiguity makes it difficult for the rater. Form B clearly identifies Task as being the issue and identifies one of four Task items for assessment. Each item can have either positive or negative contributions. In summary, form B is preferred over form A.

It is important to provide external descriptions of the criteria or standards. Otherwise, raters tend to create internal standards- standards selected based on one's own performance or a performance judged to be similar to one's own^[68, 69]. Consider forms developed to rate a clinician. Figure 2 shows four different rating forms. Form 1 gives no details of the goals; it only lists "effective clinician" and provides no measure of the criteria. The rater is expected to pick some number between one and ten. What is acceptable or outstanding to one rater, will be inferior to another. No standards are given, and so each rater will create personal and different internal standards.

Form 2 offers at least some description of the skill being considered: the "knowledge" that the clinician brings to the patient-doctor encounter. However, the term "knowledge" is ambiguous; different raters will use different internal criteria in choosing the box "meets objectives".

Form 3, in Figure 2, gives more description of the goals by listing three attributes under "knowledge" that an effective clinician is expected to display. Some criteria are given to help a rater understand what "meets objectives" means. However, the term "solid knowledge" and "common problems" are ambiguous. What is *solid knowledge* to one rater is not solid knowledge to another.

"I rated you low because you knew very little about diphtheria."

"Diphtheria is not a common problem in this area. Why should I be expected to know about diphtheria?"

responds the resident being evaluated.

Although form 3 is a marked improvement over forms 1 and 2, the form still has ambiguous words.

Form 4, in Figure 2, gives a more detailed and less ambiguous description of what is expected. True, a list is not given of the 38 illnesses but, at least we know that we are expected to know 38 and not just 5. This elaboration on the goal allows the rater to check or circle the particular deficiency from the list that forms the basis for the rating.²

² More information about these rating forms can be obtained from the authors.

Criteria-referenced, rather than norm-referenced, assessments^[69] should be used. The use of norm-referenced assessments means that one's performance is compared to another's instead of being compared to external standards defined by the criteria. Norm-referenced leads to competition that is contradictory to the cooperative atmosphere expected especially in PBL.

2.2-3 Training the assessor

No matter who does the assessment, the assessors should receive training in assessment. Some use videotapes of PBL sessions as training devices to train observers in completing well-designed rating forms. We have used a 6 hour workshop on assessment to train either tutors or students^[60].

2.2-4 Addressing the issue of self-directedness

Savin-Baden^[20] and Barrows^[21] raise the issue of assessment in the context of self-directed learning. Is the assessment consistent with the student-generated learning objectives? Technically this is a non-question if the PBL experience is well-designed. As mentioned previously, the program design starts with the faculty and their creation of the learning objectives and criteria for the learning experience. The faculty translate those objectives into a problem statement that must be well-cued so that the students generate learning objectives that are identical to the faculty's. The issue then becomes one of perception. Do the students perceive ownership of the learning process with assessment being part of the process? Our recommendation is to use self and peer assessment as much as possible.

3. Forms of evidence: options for documenting and measuring knowledge acquired

A wide variety of forms of evidence have been used^[26]. These include

- Written tests and exams: such as multiple choice questions (MCQ), essays, modified essay questions (MEQ), written problems to solve and written concept maps.
- Written forms of evidence related to their learning-teaching-problem solving process: such as plans and use of resources, study and teach notes, elaboration of the knowledge, a solution to the problem, and written learning contracts and plans.
- Rating of individualized activity such as the portable patient problem pack and computer simulations or of interactions with simulated patients/systems via simulated patient or trouble shooting triads.
- Direct observation and rating of the performance such as oral presentations, oral exams.
- Direct observation and rating of a group tutorial or specialized group activity.
- Interrupted problem solving activity such as the triple jump, objective structured clinical examination OSCE or PBEE.
- Pre and post tests.
- Reflective journals, portfolios.

These can be used as summative or formative assessments.

In presenting some of these options we hope to provide multiple forms of evidence from which you might select the ones most appropriate for your environment. The first seven options relate primarily to the quality of the knowledge learned. Options eight and eleven provide evidence for

both the knowledge learned and the process. Options twelve to nineteen relate primarily to process skills associated with PBL.

● Option 1: ***Individual Test and Exams of the knowledge, TETK.***

Exams and tests can be created to give individuals a chance to demonstrate that they understand the new knowledge. These tests can be written or oral and given as spot-checks or formally built into the program. The TETK must be consistent with the learning goals created by the students. The tests can be created, and assessed by, the teacher, peers or self.

Some popular formats included MEQ and MCQ. In the MEQ students are given an initial case and asked to respond to a progressive series of questions or tasks about the case. For example, given a brief problem, task: list hypotheses. Next task: list questions you would ask. Next: given the following new information, what are your hypotheses now? Students are not allowed to backtrack to previous tasks.

Barrows^[21] describes the use of faculty-generated MEQ to assess the information the student should bring to mind while working with the patient immediately following each case. McPherson et al.^[70] describe the use of modified essay questions, MRQ.

Our experience has been to use a faculty-generated three-hour written examination at the end of the course and to have student-generated and student-marked tests at the end of each PBL case. For the latter, after each PBL case cycle, groups of students prepare test questions based on the student-generated learning objectives. Tests questions from one group are given to another group to solve in writing. The group's answer is then marked by a peer from the group that posed the question. The teacher monitors the process and grades the quality of the posed question and answer and checks the validity of the peer mark given to the group that "solved the problem". Monitoring the questions is important because students may not be skilled in crafting questions. For example, some groups pose obscure questions unrelated to the learning objectives or give questions that are too complex to answer in the time available. For the class of 2005, for the first cycle, the average marks for the questions posed by 11 groups was 8.8; cycle 2 was 8.1 but by cycle 3 it was 9.4.

Another option is to randomly call on one individual from each PBL group. The individual's performance becomes the group's performance. This approach is used in cooperative learning groups to ensure that all of the individuals have learned the subject knowledge.^[50]

● Option 2: ***Progress test*** ^[72-76]

This is a special form of TETK that is a summative MCQ written examination of the full range of knowledge expected from the complete program. What is unique is that all students in all levels write the same examination about three times a year. Students at the first level may have few questions that they can answer but the number of questions and their success rate increases as they progress through the program. This provides students and faculty normative information about the acquisition of knowledge. Studies^[75] suggest that this form of assessment does not

interfere with the self-directedness elements of PBL.

The option has been used in medical schools where PBL is used throughout the whole program.

● Option 3: ***Student summary of the quality of knowledge learned.***

Based on the student-created learning objectives, an individual could write a summary of the knowledge learned, its relationship to previous knowledge and elaborate that knowledge. This could be marked by peers, self or tutors.

Alverno College^[77] uses a variation called the “critical learning incident”. Here the student identifies a learning experience where something noteworthy occurred. In this reflection the student identifies where the incident occurred, who was involved, how typical this incident was in their experience, what happened, what they thought and felt at the time, what was intended, what they think and feel now, and what they learned.

● Option 4: ***Individual concept maps of the knowledge.***

Individuals could create concept maps representing the new and previously known knowledge. Novak and Gowin^[78] give suggestions, examples and methods of assessing. They emphasize the importance of

- writing the relationship on the line connecting concepts,
- using a hierarchy that follows the principles of valid classification: the classification does not have faulty coordination or faulty subordination,
- including cross links between different sections of the hierarchy,
- providing concrete examples that are valid instances of the concept.

More details are available^[79, 80].

Angelo and Cross^[81] describe the use of concept maps to monitor classroom learning, CAT 16. Akinsanya and Williams^[82] describe their use of concept maps in nursing.

A variation on the concept map is the symptom-cause map important in clinical problems in health sciences^[83] and in trouble shooting problems in engineering^[49, 84].

● Option 5: ***Individual teach notes***

In PBL, individuals contract with the group that they will learn new knowledge pertinent to one or two of the learning objectives and teach the group members that knowledge.

As an aside, we have found it useful, prior to this activity, to provide a training workshop^[23] and to provide all members of every group with the scores of inventories related to learning styles (Perry, Lancaster approaches to studying, Jungian typology and Kirton inventory^[39 - 41]). This helps each student address the teaching task^[40].

Our students create teach notes that are given to the group members. These teach notes are assessed by the tutor. Teach notes have been used as evidence for students in a business program^[25].

● Option 6: ***Peer feedback about the quality of the knowledge brought to the teaching task.***

Peers can give feedback about the quality of the knowledge demonstrated when a peer taught.

The form we use^[26, 36] asks peers to rate

the Quality of the knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

Other dimensions can be included in this form that relate to the process. This is discussed in Option 15.

The feedback can be given directly to the instructor/tutor or to the student. In our MPS program, the student collects all the feedback and includes this as evidence in his/her assessment journal. The assessment journal is described in Option 16.

- Option 7: *Group solution to the problem.*

Once the students have contracted with each other to learn the required knowledge and to teach each other that knowledge, the group then uses the knowledge to solve the problem. We could use the quality of the group solution to the problem as evidence of the knowledge learned. This is a group mark. Individual contributions can be assessed based on self and peer assessment^[85] using a form similar to Table 4.

4. Forms of evidence: options for documenting and measuring knowledge and skill acquired

The next five options gather evidence about both the product (the knowledge learned and applied to solve a problem) and the process (such as the lifelong learning skills, problem solving, critical thinking). The first option was developed for testing individuals one-on-one; the second option, for individuals in the context of a large class.

- Option 8: *Evidence about both the process and the knowledge learned : the Triple Jump.*

For PBL, the McMaster Faculty of Health Sciences developed three structured activities^[24, 26, 39, 86, 87] to assess the process and the knowledge. These three activities are:

1. In response to a problem situation, students define the problem and make a prioritized list of new knowledge that they need to learn to solve the problem. This is a 30 minute oral interaction between the tutor and the student.
2. Students self study and privately synthesize the new knowledge they selected as their top priority. Students are allowed two hours. Each writes outline notes that will be judged on the efficiency in sticking with a realistic task, the knowledge resources consulted and the ability to locate key information and the quality of the note-taking and referencing.
3. Students meet again with their tutor for 30 minutes. They respond to further questions from the tutor to illustrate the process used, the new knowledge gained and how they might use that knowledge to solve the problem. Example criteria include the ability to present and synthesize ideas, the ability to pose questions about the learning issues that were not explored and the quality of the students self assessment.

A rating form is used by the tutor. The evidence would be the list of learning issues, the written outline notes and the tutor and self assessments.

● Option 9: *Evidence about both the process and the knowledge learned: Branda's modification of the Triple Jump for large classes, PBEE.*

Branda^[88] modified the Triple Jump for use with one teacher and a class of 100 to 150 students. In a 50 minute class, in response to a problem situation, each student lists four learning issues and prioritizes and justifies his/her top two issues. For the next class, each researches his/her top two issues and prepares a two-page summary. In the next 50 min class, each answers two test questions, prepared and personalized by the instructor. In class they can consult only their two-page summary notes. Branda acknowledges that this is a lot of work but that, for any problem scenario, a bank of one to two dozen test questions covers all of the different learning issues generated by a class of 150 students.

The criteria developed by Branda are:

For Stage 1: Issue identification: clarity of issues and correctness of context statements;

relevance to the learning objectives for the overall course and to the problem situation.

For Stage 1: Research and study issues: appropriateness of the issues identified and justification of the choice of issues.

For Stage 2: Knowledge and understanding of the area of research: quality of the answers to the two questions.

● Option 10: *Evidence both about the process and knowledge: critical instance cases*

Critical instance problems provide an opportunity to assess student's performance relative to knowledge and process. In health sciences these are referred to as clinical events^[33, 89]; in engineering, as trouble shooting problems^[49, 90]. For the process skills, target behaviors have been described for health professionals^[89, 56] and for engineers^[41, 49] and goals and criteria have been published^[41]. To gather evidence about student performance, the performance situation involves three elements: a) the student clinician-trouble shooter, b) the patient or system that displays symptoms and responds to tests, and c) the assessor, observer. The variation is usually in the format of b. The "system" could be a person trained to be a simulated patient^[33]; or trained to respond as the "expert system"^[49]. The system could be a deck of cards as in the portable patient problem pack^[91] or the patient management problems. Difficulties in using the latter for the purpose of determining a "mark" have been described by Swanson et al.^[92]. Another option for presenting the case is a computer simulation^[33, 90].

The forms of evidence relate to the script of questions and actions requested, a rating prepared by the observer, a comparison of the cost and the questions/actions posed with those of successful/experts and reflections about the process. The choice depends on the purpose of the assessment: to provide a "mark" or grade or to develop confidence and skill. In our MPS program the assessment was primarily to develop confidence and skill. The "mark" was based on the reflective journal, Option 16.

● Option 11: *Evidence about both process and knowledge: The OSCE*

The Objective Structured Clinical Examination, OSCE, is similar to a modified essay question, described in option 1, except here students rotate through a series of timed, 5 minute stations. At

each station, students are given a different task to do or asked to perform part of a physical examination or required to take a focused history or interpret data. Information is divulged in a preset sequence. For more see Fliegal et al.^[93].

5. Forms of evidence: options for documenting and measuring process skill acquired

The next options offer evidence mainly about process skills. For the sake of this discussion, the focus is on the acquisition of lifelong learning skills.

● Option 12: *Evidence about individual's attitude toward learning and approach to learning.*

Perry's inventory^[27, 31, 32] and the Lancaster Approaches to Studying Questionnaire,^[93] LASQ (or equivalent^[94,95]) are questionnaires about:

- One's role in learning (Perry). The first five scales are the most appropriate. Typically students leave four year colleges with levels 3 to 4. Level 5 is most consistent with an attitude helpful for lifelong learning. For example, Pavelich and Moore^[96, 97] report that freshman engineering students rated average values of 3.27 and they graduate as seniors with scores of about 4.27. These students are in the unique EPICS^[98] program at the Colorado School of Mines. These freshman scores are higher than those reported by Allen^[99] of 2.3 to 3.1 and by Marra et al.^[100] of 2.9. Marra et al. found that registration in their design course increased the freshman scores to 3.29. Fitch and Culver^[101] report values for seniors as being 2.8 to 3.1. For the MPS program,^[9] scores for sophomores have been in the range 2.7 to 3.4; for juniors, about 3.5 to 4; and for seniors, 4 to 4.7.

- The inventory (LASQ) explores one's preference among three options in learning: 1) surface or rote learning; 2) deep learning or a search for meaning and 3) strategic or work hard and use whatever approach will allow one to succeed. Typically students graduate with a preference toward *rote learning* whereas one hopes a lifelong learner will *search for meaning*. For example, students enter college with the distribution 15, 13 and 15 for rote, meaning and strategic respectively. If the college program continues with primarily formal lectures, students graduate with a statistically significant increase in rote learning. On the other hand, if the program includes experiential activities, projects and problem-based learning, the students tend to shift toward a search for meaning. For example, in a longitudinal three year study for the same cohort (N = 60) in the MPS program^[9] that includes PBL and experiential components, in three years that rote decreased ($p < 0.035$), meaning increased ($p < 0.027$)^[102]. Coles^[103] compared the effect on cohorts of students in one year in lecture program versus those in one year of a PBL program. Over one year those in the lecture program showed an increase in rote ($p < 0.01$) and a decrease in meaning ($p < 0.001$). Those students in the PBL program showed a decrease in rote ($p < 0.05$) and no change in the search for meaning. Students in a five year, inquiry program called Engineering and Society, showed a decrease in rote and an increase in meaning with ratings 12.6 and 16 respectively. Students in a PBL Theme school had ratings of 13.3 and 15.5 for rote and meaning respectively.^[104] Other inventories useful for assessing other process skills are available^[39].

● Option 13: *Test and Exams in Process Skills, TEPS.*

Based on the goals for process skills given in section 2, create examinations that test the achievement of the published objectives for lifelong learning skills. Some example questions are given in Resources Chapter D ^[23] and in Table 5.

● Option 14: *Self assessment of achievement of target skills for lifelong learners.*

Form **3600**, given in Table 2, lists the target skills and attitudes for lifelong learning. This form can be completed by individuals periodically throughout the semester and throughout the program to reflect their journey toward skill in lifelong learning.

● Option 15: *Peer and self assessment of individual contributions to the learning.*

As an extension of option 6, where the focus was on the quality of the knowledge, questions enlarging the scope to include the process of lifelong learning can explore:

the Quality of the instruction: he/she was here on time, the presentation focused on the new knowledge with good choice of material and medium; effective communication and good resource material was supplied.

the Additional follow-up needed: responses range from “no additional self study needed” to “I must study this subject on my own; I learned nothing from the presentation”.

Peers also list the five strengths of the presentation and two areas to improve.

As was done in Option 6, the feedback can be given directly to the instructor/tutor or to the student. In the MPS program, the student collects all the feedback and includes this as evidence in his/her assessment journal. The assessment journal is described in Option 16.

● Option 16: *Reflective assessment journals*

Reflective self assessment journals can be written for any of the process skills. For example, for lifelong learning skills, the goals and criteria are created, as suggested in section 2. Individuals gather evidence about his/her own achievement of the goals: reflections, peer feedback, learning contracts, teach notes. Individuals gather evidence after each PBL cycle or case. Examples are available.^[23] The elements included in the a reflective assessment journal typically are:

- a comparison of how well one achieved each objective before and after the workshop,
- a critique of the pre- and post test results,
- the validation form given in Table 1,
- a summary of new ideas and behaviors discovered from the workshop,
- for each objective, a list of the pertinent evidence and a claim as to the degree to which one has demonstrated completion of the objective,
- evidence of how the skills have been used in other educational contexts and courses,
- evidence of how the skills have been transferred and used in everyday life,
- conclusions and summary of achievements.

The evidence used by the students includes Options 5, 6, 14, and 15.

● Option 17: *Portfolio about skill in lifelong learning.*

A portfolio is a collection of evidence of “best” work. Mourtos,^[105] for example, asks students to include assignments, tests, enrichment activities and an overall reflection about the learning. Whereas Option 16, reflective assessment journals, is structured around faculty-generated goals for skill in lifelong learning and assessment, the portfolio tends to allow students to select materials that represent their best work. Ideally the Portfolio should have a clear summary by the student of the skills they have achieved as demonstrated by the materials included in the portfolio. Mourtos recommends the development of extensive marking criteria and provides a general format for the portfolio. He found that markers spent 30 to 45 minutes marking each portfolio. We would add that the marking criteria should be published and given to the students at the beginning of the semester.

● Option 18: *Learning plans for lifelong learning.*

Learning plans that identify learning goals, learning questions/objectives, course objectives, learning resources and strategies, evidence and assessment and target date^[106] are another form of evidence that has been used effectively in the nursing program at McMaster University.

● Option 19: *Other options.*

The CATs listed by Angelo and Cross^[81] have been popular possibilities to assess the “soft skills”. The CATs are a collection of options to monitor classroom learning, but these can often be converted to forms of evidence if the appropriate goals and criteria are made explicit. For lifelong learning skills, few CATS, besides concept maps, are applicable. The use of CAT 35 (assessing students’ awareness of learning goals) and CAT 36 (self-assessment of ways of learning) were described in courses (p. 79 ff) and may have potential in some contexts.

6. Example assessment of student performance in PBL

Since 1982, in the Chemical Engineering program at McMaster University students learn the five principles of assessment and develop skill in creating observable objectives, identifying measurable criteria, completing assessment evidence and writing self assessment reflective journals in a six hour workshop^[39, 41, 60]. This addresses the sixth issue in practice described at the beginning of this paper. Before they experience PBL students also have workshops on team skills (2 h), identifying personal uniqueness especially as it applies to group work and learning styles (2 h), conflict resolution (2 h), stress and time management (4 h) and problem solving (14 h). Immediately before the first PBL sessions, we introduce students to the unique characteristics and expectations of the PBL learning environment. The amount of detail we use has evolved over the years. Initially we showed a videotape showing students in PBL, and provided a one hour overview of the expectations. This had mixed success. In 2005 we had a one-hour lecture-interaction in which we rationalized the choice of PBL as a learning environment and described the underlying principles of how case problems were created. We basically addressed the question “*What’s in it for you, the students?*” We related how, traditionally, instructors publish learning objectives for every course and how in PBL, instead of handing students the course learning objectives, we pose professionally- significant problems that are *cued* so that the

students will generate learning objectives equivalent to the instructors. Teachers monitor this process to ensure that each group is learning the “right material”. The case problem should generate about 6 to 7 learning objectives each requiring about one to two hours of “learning time” and one to two hours to create effective teach notes for a total of about 2 to 4 hours of homework per group member. This provoked a lot of discussion and very probing questions. What seemed to be helpful to the students was a sense of direction behind the activity, the teacher’s validation of the learning objectives and the clarification about the time commitment. The required text for this course is Woods’s “How to gain the most from PBL”^[27].

We provided a one-hour workshop on how to search for cues, generate learning objectives, how to research and teach and how to prepare effective teach notes^[39]. In addition, we had a one hour class time for the group norms meeting. The research on the effectiveness of this approach is reported elsewhere^[40].

So that students get the most from their PBL experience, we recommend these activities be done regardless of the form of PBL used. Without such preparation, our experience is that students have the misconceptions that *assessment* is “licence to give yourself (and your friends) 100%” and that PBL is a learning environment where the teacher doesn’t do his/her job and the student can learn whatever they want.

Now consider the form of PBL we use. In our particular context, we use small group (5 to 6 students), self directed, self assessed, interdependent problem-based learning in two required courses in an otherwise conventional four to five year curriculum³. The PBL sections are for knowledge in engineering economics and process safety and, for each, there are 4 to 6 case problems with one case being considered each week. These are tutorless groups since one instructor is available for classes of 60 students. More details about our context of using PBL in an otherwise conventional program are available^[9, 107, 108].

We assess both knowledge acquisition and process skill development. The learning objectives and criteria for the subject knowledge are generated by the student groups and monitored by the instructor (as described earlier). The learning objectives for the process skills were developed by the faculty based on research evidence and given to the students. These were challenging to develop and evolved over 13 years. They are available^[39, 41, 109].

Concerning the forms of evidence, in this paper we have listed, with succinct descriptions, a wide range of options for assessing the performance of students in PBL programs: how well do they understand the knowledge and how well can they apply that knowledge? how skilled are they with the process skills?

Some options for small group, self directed, tutored PBL that is used in every course (Health Sciences, especially at McMaster University) include options 2, 8, 11 (the progress test, the triple jump and OSCE). There is tutor and peer assessment but we am not aware of the details.

³ The four year program leads to an accredited degree in Chemical Engineering; the five year program, to accredited degrees in Chemical Engineering and Management, Chemical Engineering and Society and Engineering and Chemical Engineering and Bioengineering.

For our small group, self directed, self assessed, interdependent and tutorless PBL the forms of evidence include options 1, 5, 6, 12, 13, 14, 15, and 16 (Tests and exams, teach notes, peer feedback, attitude measures, self assessment and reflective journal writing).

In practice, four elements have been used as the basis of the final mark or grade in the course. These are 1) a written, three hour conventional examination, 2) the student-generated tests, 3) the reflective journal and 4) an interview.

The written, three-hour conventional examination is created and marked by the instructor and includes questions related to subject knowledge and process skills. All questions were created in the context of the learning goals and criteria (whether they have been generated by the student groups or by faculty). This is a combination of *Options 1 and 13* since both knowledge and process skills are tested. The questions are not multiple choice; they are usually problem to solve. These have been monitored by visiting external engineering accreditation teams.

The student-generated tests for knowledge that are produced at the end of each PBL cycle have been described in *Option 1* earlier in this paper. The team marks (for creating the test question, developing and answer and marking scheme and for answering another group's questions) represent about 10% of the term mark.

The self assessment reflective journal, *Option 16*, is written by the student for each process skill. In the penultimate course, the focus varies from year to year but always includes lifelong learning, and group skills and may include conflict resolution and asking questions. In the final year course, the focus includes skill in chairperson, lifelong learning and trouble shooting. An journal is written after each PBL cycle, after each meeting when the student was chair, and after each trouble-shooting triad activity. Although the total number of journals and the marks vary from year to year, these usually represent about 40% of the individual's final term mark. (The other term marks are for projects not directly related to PBL since only a portion of this course is PBL.) The reflective journal is *Option 16* but in our context also includes forms of evidence described in *Options 5, 6, 12, 14, and 15*.

The personal interview addressed the evidence the student provided for the knowledge and process skill development. This usually accounted for 25% of the term mark. The personal interviews considered all of the evidence from *Options 1, 5, 6, 12, 13, 14, 15 and 16* (except the written final exam since the interview was before the exam was written). The personal interview was used for the first 10 years of our journey with PBL but was discontinued because the mark based on the interview was within 3% of the marks acquired from the other options. Since we use $\pm 3\%$ as a guideline for interpreting marks from conventional written examinations, and as the class size increased toward 60 the commitment the time by instructor became onerous, we elected to drop this option. Our experience is, for example, that the difference between final written exam mark and the self assessment mark was -0.8% with a standard deviation of 5.84 for $n = 265$ students.

For the final mark in the course, the student would receive the best of the 60 - 40 weighting for the written final exam mark and the term mark. An alternative to this default weighting was that students could contract to have a weighting anywhere between 10 and 90%. Whatever weighting the students chose, for over 75% of the students there was less than 5% difference among the

different marks. Details of some of the earlier results are given in Woods, Chapter 5^[26].

In summary, students should receive formal training about the principles of assessment and how to self assess. Then, the actual forms of evidence used should be selected based on what would work in your environment. We described the forms we have used since 1982. Our approaches have changed over the years. .

7. Summary

1. Five principles of assessment provide a framework for developing and using evidence for the assessment of student performance.
2. Any assessment requires published goals and measurable criteria. Some examples were given.
3. Assessment should be based on a wide variety of forms of evidence.
4. Examples are given of forms of evidence, and their use in different programs, for the assessment of knowledge acquisition, for the combination of knowledge acquisition and process skills used to apply that knowledge and for the process skills alone.

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Table 1. Validation form for learning objectives

Case problem _____ Date _____

Issues (to be completed by the tutor)

Number identified: 1 2 3 4 5 6 7 >7

Agreement with tutor <50% 50% 60% 70% 80% 90% 100%

Knowledge/skills to be learned (to be completed by the student)

Consensus among group little some a lot complete

(to be completed by the tutor)

Agreement with tutor's list little some a lot complete

Learning objectives (to be completed by the tutor)

Quality poor fair OK good excellent

Learning (to be completed by the student)

Quality of questions asked during the teach session none some astute excellent

Willingness to continue to contribute <50% 50% 60% 70% 80% 90% 100%

Your Attitude (to be completed by the student)

Perry shift 2 3 3.5 4 4.5 5

Table 2. Some evidence-based targets for Lifelong learning skills, © copyright, Donald R. Woods, 1999

Lifetime learning we define as learning how to learn so that whatever comes our way we empower ourselves to master the new knowledge.					
Evidence-based targets	Progress toward internalizing these targets				
	20%	40%	60%	80%	100%
● Consider peers and classmates as resources to help me see my learning needs, to help me plan my learning and to provide new ideas so that I can learn from them.					
● Able to assess learning needs realistically.					
● Able to create observable, unambiguous and achievable learning objectives to match or satisfy my needs. Use these to assess progress.					
● Can relate to teachers and instructors as resources, facilitators and helpers rather than as the sole source of knowledge. Have acquired an attitude toward learning comparable to Perry level 5.					
● Able to identify people and material resources needed to achieve my learning objectives.					
● Able to shift from being a dependent learner through being an independent learner to being an interdependent learner.					
● Able to devise a time plan and stick to it reasonably well.					
● Willing to assume responsibility and ownership for the tasks in learning: (goal setting, resource identification, learning, assessment).					
● Meets contract commitments to teach others.					
● When teaching others, uses the principles of learning and addresses differences in learning styles (instead of "reporting information" and					

expecting the learner to sort it out).					
● When learning a “difficult” topic, willing to accept the challenge to unravel the complexity (instead of skipping over it and “hoping it won’t be on the exam”).					

Table 3. Goals for lifelong learning
MPS 36 Self-directed learning or lifetime learning

1.1 given a term listed under "concepts introduced", you should be able to give a word definition, list pertinent characteristics and cite an example.

2.1 Given a problem, you will ask questions, explore issues so that within 30 min, as a group of five, you will be able to identify all of the five to six major issues, and these shall agree within 95% of those identified by the tutor.

2.2 Given a problem, you will be able to list the possible knowledge you would need to know to solve the problem; your list should agree within 80% of the list of others in your group and within 85% with the list of the facilitator/tutor.

3.1 Given a problem, a list of the possible knowledge and resource available, you will create learning objectives and methods of assessment. These will be 90% acceptable according to the criteria for self-performance assessment (in MPS 3)

3.2 Given the learning objectives and methods of assessment, you will be able to identify reasonable and pertinent sources of information and be able to allocate the resources to achieve the objectives in the time available.

3.3 Given the learning objectives, you will create for yourself examination questions that are consistent with the objectives. These will be judged by peers and or tutor to be 90% acceptable.

3.4 Given that other members of the group have acquired key knowledge pertinent to the situation, you will ask questions so that you can learn from them the knowledge you need. You will interact such that they will rate a willingness above 70% to continue to share information with you.

Concepts introduced

Peers as resources, Perry's inventory, learning objectives

Table 4. Form **2804**, Self and peer assessment of contributions to team work (developed by C.M. Crowe and used with his permission)

Name _____	
Assessment of the group	
(10) Group worked well together, making the project more interesting. (5) Group usually worked well together, with occasional difficulties (0) Group could not work together at all, making the project more difficult	

Please enter a mark from 0 (worst) to 10 (best) in each row, for yourself and the other members of your team or group. If you cannot make an assessment, enter U for Unable to Observe. Your assessment should be about performance and should be based on evidence you have seen or heard.

<i>Enter your initials in the first cell to the right and those of the other members of your group in the remaining cells</i>	self					
Leadership						
(10) Provided direction, inspired the others (5) Willing follower, took direction easily (0) Frustrated the group, blocked progress, criticized the others						
Cooperation						
(10) Worked readily with the others, contributed to the group work (5) Cooperated with occasional prompting (0) Rarely contributed, worked mostly alone, had to be coerced into cooperating or would not cooperate.						
Initiative						
(10) Produced good ideas which helped others, solved problems (5) Accepted other's ideas and improved on them (0) Criticized other's ideas, never contributed his/her own ideas'						
Attitude						
(10) Positive, encouraging the others to work better (5) Neutral, worked well with the group without enthusiasm or grumbling (0) Negative, complained about the project, worked unwillingly with the group						
Computation						
(10) Helped others to understand and use computer tools better (5) Good but not innovative in using the computer tools (0) Uninterested or unable to use computer tools effectively; needed constant help to become useful at computing						
Effort						
(10) Worked very hard on tasks assigned by the group or on his/her own (5) Worked reasonably hard, given other courses and commitments (0) Did not work much at all, tasks were either not done or were unsatisfactory						
Research						
(10) Found many additional published papers, contacts or internet sites which greatly helped the project (5) Read only the assigned material and used that knowledge effectively (0) Had not read any material about the project, relied on others for information						

<p style="text-align: center;">Communication and written reports</p> <p>(10) Organized and wrote major parts of the report (5) Contributed his/her share of the writing of the report (0) Made little or no contribution to writing of reports.</p>						
<p style="text-align: center;">Individual assignments</p> <p>(10) Did all of them on his/her own, helped others (5) Did most of them, perhaps with some help from others (0) Either did few of them or most of them handed in were copied.</p>						
<p style="text-align: center;">Pertinent technical/subject Knowledge</p> <p>(10) Excellent grasp of the technical fundamentals for this project and shared and used this effectively (5) Reasonable understanding of the basics and used this effectively (0) Little or superficial understanding, relied on others</p>						

Table 5 Test and Exams in Process Skills, TEPS, for "Lifelong Learning"
MPS 36: Self-directed learning: Example assessment tasks:

1. For the learning goal "to explore the environmental issues related to the Red Hill expressway" (the problem posed in PBL Case 3)
 - (a) If pertinent, break this into further subgoals.
 - (b) Rewrite the subgoal in "observable terms."
 - (c) Create at least one measurable criterion that you be used to measure success in achieving the subgoal.
 - (d) Write out one type of evidence you would collect to show progress toward your subgoal.
2. Given in Table Z are the results of the Jungian Typology and the LASQ inventories and the Perry level for all the members of your group. The handout that Ralph has prepared for the teach meeting is given in Table R. Critique the handout based on your interpretation of the learning needs and preferences of the members of the group.
3. List the learning preferences and level of Perry development for each member of your group. Document the evidence that you used to reach this assessment.
4. For the PBL Case given in Table X,
 - a. List ten issues you think are pertinent;
 - b. Prioritize these in the context of this course.
5. Given in Table Z are the results of the Jungian Typology, the LASQ inventories and the Perry Level for all the members of your group. For the PBL case 3, reproduced in Table X,
 - a. Identify the topic you contracted to teach the group.
 - b. From the information in Table Z, outline how you would teach the group. Assume you have 30 min. Create the handout sheets you would use.

Figure 1: Example options for assessing group and individuals within groups

Form A: First of 26 entries

Helpful behaviors

Initiates and contributes ideas
Arrives on time and is prepared
Completes assigned tasks
Arrives with questions or comments
Shares knowledge

Form B: First of 8 behaviors

First of four related to Task

Observer of the task process:

Positive: orients the group, monitors, summarizes, seeks
direction, identifies phases in the problem solving process

Negative: ignores phases, asks whatever he/she wants, blocks
Is unaware of his/her contributions

Assessing Problem solving skills.

Woods, D.R., T. Kourti, P.E. Wood, H. Sheardown, C.M. Crowe, J.M. Dickson (2001)
 “Assessing Problem Solving skills: part 1, The context for Assessment,” Chem Eng. Education ,
35, no. 4, Fall, p. 300 - 307

The five principles of assessment provide a framework for developing and using instruments for the assessment for student performance and of the evaluation of the program effectiveness. Crucial to any assessment is the creation of published goals and measurable criteria that form the context for the performance of the student. Evidence should be gathered and assessed in the context of these goals and criteria. Four example sets of goals and criteria were presented.

Assessment is based on evidence of performance. Seven options for gathering evidence were described in this paper. Eight options that focus more on measuring the problem-solving process will be given in Part II. The first two options of evidence (mark the answer and tell the student the process is important) provided exam scripts in subject discipline, where correctness of the answer, subject knowledge and problem solving were being marked. We elaborated on the challenges of using conventional exams as a measure of problem-solving skill.

Woods, D.R., T. Kourti, P.E. Wood, H. Sheardown, C.M. Crowe, J.M. Dickson (2002)
 “Assessing Problem Solving skills: part 2, Assessing the process of problem solving,,” Chem
 Eng. Education, **36**, no. 1, Winter, p. 60 - 67

Assessment is based on evidence of performance.

Fifteen options for gathering evidence were described, seven in Part 1 and eight in this paper. Data from student's performance in the McMaster problem Solving program were used to suggest that:

- *Tests and Examinations of Problem Solving skills (TEPS) can be developed that are consistent with the published goals and criteria. These results, however, are least highly related among the measures.*
 - *Self-assessment and journal writing are highly related measures of problem solving skill.*
 - *The use of a written script gathered for the sole purpose of displaying ten to twenty minutes of thought processes used in problem solving was not a statistically significant measure.*
 - *We recommend using a variety of forms of evidence. We also recommend the use of a contract mark in which the goals and criteria are published and regarding which the students have some choice in the relative weighting of the evidence.*
 - *The results from exam scripts in subject discipline - where correctness of the answer, the subject knowledge and problem solving were being marked (Option 2) - gave one form of evidence, but it should not be used as the sole form of evidence. The challenges of using conventional exams as a measure of problem solving skills were described in Part 1. Even addressing these challenges as best we could, we found no relationship between the exam marks in chemical engineering subject discipline courses and any of our measures of problem solving skills.*
- For program evaluation, the results from such published tests as Basadur's attitude toward ideation, Heppner's measure of confidence in problem solving, and Billings-Moos' measure of problems solving performance and avoidance are useful for pre- and post data about the effectiveness of programs. We recommend that instruments be used, including the items on exit surveys, where benchmark data are available for comparable populations.

a Chapter for the book “Case Studies on PBL,” P. Schwartz and S. Mennin, eds., Kogan Page

They just don't pull their weight!

a180

Case Reporter: Don Woods.

Issues Raised

Individual accountability in small tutorless groups. A student complains that she is doing all the work. She says that others commit to “teach” subjects but come ill-prepared.

Background

The third year course in Chemical Engineering includes six weeks (18 hours of class contact time) of small group, self directed, self-assessed problem-based learning. I handle a class of 30 to 50 students and assign the students to groups of five or six. The groups have no tutor assigned to each group because there is only one instructor. During the first two weeks students are introduced to the skills and attitudes through a series of four, 1 ½ hour workshops. The topics for the workshops are 1) what is PBL? Why is it important for you? and managing change; 2) problem solving skills; 3) how to work effectively in groups and 4) how to be an effective teacher.

To remind students of their learning attitudes, styles and preferences, all students share with their group members the results of the Perry inventory (an instrument to explore the student's attitude about their role in the learning), the Jungian typology (which suggests student preference for theory versus worked examples, generalities versus details) and the Lancaster Approaches to Studying (which explores the student's predilection for rote learning, search for meaning or work hard in the context of the published syllabus).

In each of the weeks following the preparation workshops the students cycle through three meetings for each of the four sequential “problem cases.”

I had worked successfully with fourth year students for the past six years, but at the students' request have moved some of the PBL material into a third year class. This is the first time I have tried this approach with third year students.

For the PBL case problems, each group holds three scheduled meetings. During the first, the Goals Meeting, the students read the case, list the learning issues and have these validated by me. They contract the teaching responsibilities from the learning issues with each person contracting to return and teach the other their topic. Although I provide a written contract form, most groups create their own contract. The second meeting is the “Teach Meeting” where each person teaches with each others the topics they have researched. Each student is given written feedback from everyone in the group about the quality of the “teaching.” The final meeting is the “Feedback Meeting” where each group selects a reasonable “exam” question based on the case. Each group's question is given to another group to solve. I monitor the results of the exam questions posed and the answers created. After each cycle of three sessions, each student writes a *Reflective Report* of how well their lifetime learning skills are developing. The analysis includes the feedback sheets from the teach meeting, the example test question from the Feedback meeting, the learning objectives, and a personal analysis of the strategies used to teach and the shift in attitude about PB and the acquisition of lifetime learning skills.

Part One

A knock on my door. Maria, a conscientious B student in my third year class asked, “Can I see you a moment about something that is bothering me about PBL.”

“Please come in and tell me about it,” I encouraged.

Maria sat down and launched into her story.

“For the first case, everything seemed to go OK. Some of the teaching done by the others was “fair,” but I put that down to our first attempt at this new form. The second time around, everyone came to the teach meeting. Although we all contracted to prepare and distribute “teach notes” I was the only one with “teach notes” to distribute. I tried

my best to teach them, but they didn't seem to be paying much attention. When it came their turn, they all did a lousy job of teaching. No notes. Very superficial. No worked examples."

"I'm sorry to hear about that."

- What do you think I should do?
- What are the issues being raised by this situation?
- What is my role in this scenario? Do I go into class and tell them what should be happening? Do I move Maria to another group? Do I ask permission to sit in on her group to see for myself Maria's problem?

Part Two

Quickly, I thought through the range of issues that might pertain:

Is Maria expecting too high a standard?

Does she have a lousy group?

Did I not give them enough pre PBL training or perhaps what I offered was ineffective?

Is the method of contracting insufficient to get a commitment from all?

Are the others living up to the contract but Maria is expecting more?

Are they ready for PBL? Are the students too comfortable with the "lecture system" and they really are not ready for or are unwilling to accept PBL?

Is this an issue that will 'resolve itself' with maturity with PBL?

Is the problem with Maria? with the others in her group? with trying to introduce this at too low a level? with me and how I set it up?

I concluded that it was time to get more information to help identify a root cause.

"Who are the other members of your group?" I ask.

"Jason, Brad, Margarite and Suzelle."

I reflect on how I set up the groups. This was typical group with a mix of academic backgrounds.

Jason, an A+ student, mature and headed for graduate school eventually.

Brad, a C- student. Active in sports. Rather casual attitude about school and not working to his potential.

Margarite, C+ student. Very active in campus activities. Conscientious student working close to her potential academically.

Suzelle, B student. Transfer into the program from a work term. An unknown quantity for me and her classmates. Seems to work hard.

OK this seems like a reasonable group.

"How do you feel about your group?"

"I don't know Suzelle very well but she seems OK. I expected Jason to be a conscientious driving force in the group. The others are OK. But they're just not pulling their weight."

"Did it seem to work out OK the first time?"

"Yes, but none of us knew what to expect. In hindsight, we probably didn't do a good job."

I could follow up on this, but this seems like a group that should work well. I wonder if it is the contracting (from the Goals meeting), their understanding of the teaching task, the delivery in the Teach Meeting or their general resistance to change? To check out the potential for resistance, I asked for the Perry scores.

Maria responded, "Mine is 4.2; Jason is 3.8; Suzelle is 4.0; Margarite is 2.9 and Brad doesn't remember his. I would put him about 3."

OK, I thought. Margarite at 2.9 I expect to be struggling. She probably wishes I would lecture. She's not as ready as I would hope. Brad. Oh, that's Brad not to have his score. He's probably a little higher than 3 but... This is a typical mix. I wish they were all 5 but... Jason is a surprise. Perhaps he has succeeded so well by having a lot of mental horsepower and having learned how to use the system effectively. He may feel a little threatened with this new form and be resisting.

"How about the Lancaster scores?"

"Which ones are those?"

“The three numbers in the range 15 to 30 about strategic, surface and deep learning.”

Maria looked through her notes and handed me the summary sheets that all students completed for their group members:

Maria, high on deep learning

Jason highest on Strategic

Suzelle, Margarite and.. Brad’s is missing... these two show highest on surface or rote learning. I would expect Brad’s to be the same.

“Thanks,” as I hand the paper back to Maria without further comment.

To check out the contracting, let’s hear what they did during the Goals Meeting.

“Can you lead me through the Goals Meeting for the second case?”

“Brad was assigned to chair the meeting. He didn’t circulate an agenda although we all had an idea about what to do so that probably wasn’t a big deal. We spend the first 20 minutes brainstorming the issues and prioritizing them.

Then you checked them as 80% complete and helped us to see the additional learning objective we should include.”

“Yes, your group did a good job on identifying the learning issues. Then, how did you contract?”

“ We checked over the list; each identified a topic they would work on. We said that we would teach the same as the last time. Each person completed the feedback form about how the meeting went and gave it to Brad, and we left. ”

“ The contract was the hunk of paper saying “We the undersigned agree to meet out obligation to research, study and teach our assigned.....” Everyone was expected to sign it to help meld the contract among group members. Also, if you recall I suggested that each group discuss individual member’s preferred way of learning and that each prepare teach notes to be distributed to all members of the group. Did your group do any of that?”

“We did a bit of that the first meeting. The discussion about teaching style was brief. We just had the completed list I showed you... except, of course, for Brad.”

“What about the teach notes?”

“The first time we did agree by everyone nodding their heads. We didn’t sign anything at either meeting.” ... pause...

“I’d really like to transfer to Tony’s group. Everyone in their group brought teach notes to both meetings. I looked at them. They were good. I must get on the Dean’s honour list this year to retain my scholarship. I may want to go to grad school. I really don’t want to have my grades go down the drain because the others don’t care. You have control over that, not me!”

- What does this information tell you about the situation?
- What other questions would you like to have asked?
- Did I respond empathetically? How could the responses to Maria be improved?
- Should I have followed up on Maria’s insights about the first cycle?
- What would you do next?
- How do you respond to Maria’s request to transfer to Tony’s group?

Part Three

So far I realized that although Maria thought there was a contract to provide “teach sheets” this contract does not seem to have been created or signed. The other members did not have the expectations.

The students in this group, and probably in the others, are not as prepared as I had hoped.

For example, sophomore students, when given the choice to *select* a PBL environment, are compared, in the following table, with third year students in traditional programs where I tried to introduce PBL in the following table.

	second year cohort who elect PBL	third year cohort where I introduced PBL	Comments about the third year cohort relative to the ideal
Perry	> 4.5	3.74	unwilling to see the teacher as resource
LASQ Strategic	16	16	
LASQ surface	13	15	stronger preference for surface learning
LASQ deep	15	14	less preference for deep learning

Based on the relatively low value of the Perry inventory I should add more structure and individual accountability. The LASQ scores help students approach the teaching task. I should not directly interfere with group processing. I decided to have a brief “State of the PBL” talk with the class as a whole. I would

1. Remind all the student groups of the elements I have found critical to the success: “contracts” and “teach notes.” Some examples from the fourth year class were posted to illustrate options. Remind them of the expectation that these would be addressed in the *Reflective Report*.
2. Remind all the student groups of the implications of the Perry and LASQ data and describe how this information will help them.
3. Explain that I would try to help them by monitoring the individual progress by having class *ombudspersons* and by creating a feedback form for peer and self rating about individual contributions to the team.

In addition, I decided that Maria’s request to be transferred to another group should be denied promptly now. Here’s how I handled it.

“Maria, you recall that when I set up the groups I announced that I was assigning people to groups where I hoped each would encounter new people with completely different styles from your own. I hoped that you would have to learn to deal positively with differences. I wanted you to learn this skill while you were still in school. When you are working as a professional, you may be assigned to work with a team - a team containing members with whom you have difficulty working. You cannot request to be assigned to another team! Nor would I be helping you here if I transferred you to Tony’s group. I realize you are on the path to graduate school, and I want to help you get your scholarships. On the one hand, I see that I have succeeded in putting you in a group where you are encountering differences in approaches.. in particular differences in accepting responsibility. On the other hand, let’s see what aspects from the workshop on coping with conflicts and assertiveness might apply to this situation. Which ideas might be pertinent?”

Maria thought for a moment and then suggested, “I probably should express my feelings assertively by saying something like “When I don’t receive written teach material in the Teach Meetings, I feel frustrated because I thought we had all agreed to supply that material.” and then see how they respond.”

“That sounds good. You have modelled a good assertive statement that should open up some communication. You might add to your statement a request, “Can we talk about this?” rather than just waiting to see how they respond. In addition, since you might not be the only one experiencing frustration, I will be telling all the groups about the importance of written contracts and teach notes, and of the value of the LASQ and Perry inventories to guide in preparing to teach. I also will probably ask everyone to complete feedback forms about contributions to the group. Is there anything else I can do to help you?”

“No, I’ll try the assertiveness and hope that your general comments will help our group.”

“Please keep me posted on how it works it.”

The options I rejected were:

- To have all groups hand in “teach notes.” This would give me direct evidence about the quality of the preparation by each person. This option would make each person accountable. However, I believe that the group needed to be able to decide on their own how best to handle the teach meetings. I did not want to **require** them to create “teach notes” just for a mark or just for me.
- To have all groups hand in “contracts” because my experience with the final year students had suggested that each group handled this in different and imaginative ways.

Here is how *ombudspersons* worked. I asked the class to appoint four class representatives who would give me occasional feedback about how well the learning was progressing and offer suggestions for improvement. This worked extremely well. They raised issues that were easy to explain, rationalize and change. Above all, the students felt that I was concerned and aware of what was happening in class.

Here is the individual accountability form, the data I received and how well this worked. For the form, I listed a set of desired behaviours and criteria. Some elements I included were leadership, cooperation, initiative, attitude, effort and individual assignments. The form included example rating criteria. For example, for leadership a rating of 10 means: *provided direction and inspired others*, 5: *willing follower, took direction easily* and 0: *frustrated the group, blocked progress and criticized others*. Similar descriptors were given for each element. Each student was to rate him/herself and all of the other members. The rating forms were given directly to me and not seen by anyone else.

What were the results? Unless you see the actual numbers it is hard for colleagues to see that this really works. Here is an example of the results for Maria’s group. First, the students rated themselves as a group 8.3 out of 10. The arithmetic average of the scores for all elements on the form are given in the body of the table with the self-rating given in bold. Thus, Maria rated herself highly at 9.5 yet her overall average rating for all members of the group was 8.22. Maria was rated highly by the other members with all ranking her as first. I have added the ranking to each entry. That is, Brad rated Marie as 9.2/10, Jason 6.9/10, Suzelle 7.6/10, Margarite 6.2/10 and assigned the same average score for himself. Based on these ratings by Brad, Marie is ranked first; Suzelle, second and so on.

Group rating: 8.3 (8.3)	As seen by					Score for individual and standard deviation
	Maria	Jason	Suzelle	Brad	Margarite	
Maria	9.5 1	8.95 1	9.1 1	9.2 1	8.6 1	9.07 [0.33]
Jason	8.5 2	8.55 3	7.9 4	6.9 3	7.2 4	7.81 [0.75]
Suzelle	8.4 3	8.95 1	8.7 2	7.6 2	7.8 3	8.28 [0.59]
Brad	6.8 5	7.43 4	7.6 5	6.2 4	4.9 5	6.6 [1.09]
Margarite	7.9 4	7.43 4	8 3	6.2 4	8.3 2	7.57 [0.82]
Rating scale used by individual.	8.22 [0.98]	8.26 [0.78]	8.26 [0.62]	7.22 [1.25]	7.36 [1.47]	average of rating standard deviations 1.02

These results were obtained early in the semester. Once everyone realized that this form was some measure of accountability, this group started to communicate with each other and their performance improved. This table is representative of the results from the seven other

autonomous groups. This particular self and peer rating form worked well in that:

- The scores are relatively consistent. In this example, except for Margarite, the self rankings were consistent with the peer rankings.
- Just the fact that such rating forms were completed and the results seen by the tutor meant an improvement in individual accountability. Individuals could not get away with poor performance without receiving low ratings from their peers. The diligent workers feel satisfied that their dissatisfaction with their peer's performance is reflected through their ratings that, in turn, are seen by the tutor.

One issue remained for me. What would I do with the data? I could return the original rating forms to the groups; I could summarize the results in Tables, as illustrated above, and give these to each group; I could use this as evidence about individual performance and assign a "mark" to each individual; I could use the data in conjunction with subsequent collections of the same data to help see individual progress; or I could take no action and treat this as "gathered data." I mulled this over for a while, and thought that I might bring it to the class (or to the class *ombudspersons*) for advice. As time passed, no one asked about the results so I just took no action. The information provided interesting benchmarks for me to see the team performance. The students *knew that I knew* about their performance. I think they no longer felt that they could hide in the group.

Maria saw me in the hall about three weeks later and reported that her group was really working well. I didn't ask her to elaborate so I don't know whether it was the use of ombudspersons, her assertive statements and work within the group, my "State of PBL" address, the use of the rating form or the *Reflective Report*. Perhaps I should have asked her.

- How do you feel about the way I handled this situation?
- If you elected to use a rating form, how would your form differ from the one I used?
- How frequently do you think a rating form might be used during a semester?
- In my situation the students seem to have responded positively by just knowing that I saw the results. What would you do with the results from the rating form?
- What other ways might be used to improve individual accountability within tutorless groups?

Discussion

The two key issues in this case are how can PBL be used in large classes where individual student groups do not have a tutor and what might be done to overcome uneven participation in groups.

Working with tutorless groups:

PBL has been successfully used in large classes where the student groups are without a tutor (1-4). Don's particular approach is to:

- Spend about 6 hours of workshop time *upfront* to develop the student's confidence in their

skills. He believes that the students need these because the groups are autonomous, and the students should have the skills needed to solve their own problems. By way of contrast, in programs where a tutor is available for each group, the tutor is trained in these skills: problem solving, group process, conflict resolution and sensitivity to how to teach. For tutorless groups, Don develops the skill for each group member. These are seen as valued outcomes of the program. In this Case, Don could use Marie's familiarity with and skill in assertiveness as a suggestion for dealing with the apparent conflict. Details about how to run the workshops are available (5).

- Empower students with self awareness of their preferred styles of learning and those of the peers in their group. Don has considered a variety of questionnaires and has settled on two: Jungian Typology (6) and the deep versus surface learning style using the Lancaster Approaches to Studying Questionnaire (7). In Part Two of this Case, the Lancaster scores provided Don with key information that helped him diagnose potential areas for conflict. At that time, Maria did not seem to appreciate the significance of this information. Later in Part Three, Don again used the LASQ data to help him realize the difference between the approaches taken by his third year students and the target approaches. Little is said in this Case about the implications of the Jungian typology. Don uses the S-N dimension of that typology to help students identify their preference for teaching by examples and details (a preference for dominant S students) compared with a preference for teaching theory and global issues (a preference for dominant N students). More is given in the section B.6 on a workshop on Self-directed Learning (5).
- Try to give the PBL approach the best chance to succeed. Unless students have chosen to enter a PBL program, most prefer the "same old lecture song and dance." (8) Students have learned how to make the familiar lecture system work well for them. They resist change, and PBL is certainly a change! Don took five effective actions but missed on three additional components that, for this class, were critical. The five effective actions were:
 - + He explained why PBL was such an excellent learning environment and used a videotape to show the expected behaviours in the three PBL meetings.
 - + He ran a 1 ½ hour workshop on how to manage change (details are available, 5).
 - + All students completed the Perry inventory,(9) and he used the results to help the students understand the attitude shift expected and Don's role as a tutor. More about this a little later.
 - + He assigned a text written to help students understand PBL (10).
 - + Together with the class he did a "force-field analysis" of the factors that would make this a great success and those that impede the success (as recommended in the text, 10).

But Don missed on three issues that are critically important when introducing PBL.

- Don should have set up *ombudspeople* right at the beginning to provide him with ongoing feedback about how well things were progressing. In the Case, he didn't do this until after Maria came to see him, in Part Three.

- He should have paid more attention to the differences in Perry scores between the

“ideal” and his third year students. He had the data, as described in Part Three. He used it a bit but he should have gone further. Here is some background about Perry and the Perry model. For any change in learning environment, Perry’s Model of Intellectual Development (9, 10) (or an equivalent model such as King and Kitchener’s Model of Reflective Judgement (11)) provides a good framework to help students cope with the expectations of the new environment. According to William Perry, a Harvard psychologist, people progress through some or (in rare cases) all of nine stages of development. Most college students can be found on Levels 2–5:

- Level 2 (Dualism). Every point of view is either right or wrong. All knowledge is known and obtainable from teachers and texts, and the student’s task is to absorb what the teacher presents and demonstrate having done so by repeating it back. Confusion occurs if the text and the teacher do not agree. Dualists want facts and formulas and don’t like theories or abstract models, open-ended questions, or active or cooperative learning found in PBL.
- Level 3 (Multiplicity). Most information is known, but there are some fuzzy areas with questions that still have no answers but eventually will. The teacher’s role is both to convey the known answers and to tell students how to learn. Students start using supporting evidence to resolve issues rather than relying completely on what authorities say, but they count preconceptions and prejudices as acceptable evidence and once they have reached a solution they have little inclination to examine alternatives. Open-ended questions and cooperative learning are still resented, especially if they have too much of an effect on grades.
- Level 4 (Transition to relativism). Some knowledge is known, but some is not and probably never will be. Students feel that almost everything is a matter of opinion and their answers are as good as the teacher’s. The teacher’s task is to present known information and to serve as a role model that can be discounted. Independent thought is valued, even if it is not substantiated by evidence, and good grades should be given to students who think for themselves, even if they are wrong.
- Level 5 (Relativism). Students in relativism see that knowledge and values depend on context and individual perspective rather than being externally and objectively based, as Level 2–4 students believe them to be. Using real evidence to reach and support conclusions becomes habitual and not just something professors want them to do. Different knowledge is needed in different contexts; there is no absolute truth with good answers existing once the conditions are known. The student’s task is to identify the conditions and to choose the best ideas, with the teacher serving as a resource. Students at this level are comfortable with both positive and corrective feedback.

A student at one level (in this Case the third year cohort is between level 3 and 4 as noted in Part Three) being asked to function at a higher level (ideally in PBL the students should be close to level 5) is likely to be under a great deal of stress, especially if the required level is more than

one removed from the student's current level. Their reactions to this stress account for the resistance and occasional hostility instructors often encounter when they begin to use PBL (10). In this Case, Don experienced some of that anger in Maria's request to transfer to another group and her concern about losing her scholarship. On the positive side, Don (and Maria) used the Perry information, in Part Two, to help diagnose that the group might have an attitude problem. In particular Margarite and Brad were probably just not ready to accept their new role.

Don could have helped by spending more time *upfront* in the change management workshop addressing the issues raised from the results from the Perry inventory. For example, he could have had brief role-play activities for the full class to illustrate typical responses of persons with Perry level 3 and contrast that with behaviour at Level 5. He could have worked through more activities in Chapter 1 of the required text (10).

- Don's third mistake was that he did not anticipate that uneven participation would be a major issue in tutorless groups. Ironically, he had coauthored an article that identified this as a major issue (12). Part of the role of the tutor is to create, from the beginning, a learning environment where students are both empowered with most of the elements in the learning process *and are accountable* to their peers and to the tutor. In this Case, Don faced the reality of students being able to hide in the group only when Maria brought it to his attention. Then he had to back-peddle and try to set up the ground rules **after-the-fact**. Student performance and contributions need to be made visible to the tutor -especially when the tutor is not sitting with the group! What should he have done? *At the beginning*, he should have indicated the means that would be used to make behaviour visible to all and the importance placed on such evidence.

Overcoming uneven participation in groups.

Uneven participation and lack of attendance are the top two major issues for tutorless groups (12). The options Don considered explicitly, especially in Parts Two and Three, all dealt with making individual contributions explicit and visible. He considered, and rejected, requiring that individuals hand in the learning contracts or the teach notes.

Make individual contributions visible: *Learning contracts:*

Knowles (13) advocates the use of learning contracts. For engineering students, Don had found that most groups were more willing to create their own contracts than to use a prescribed version such as the one proposed by Knowles. The emphasis needs to be on the importance of the creation of the written contract. The contract can then be used as evidence in student's *Reflective Reports* or handed in separately as evidence of performance in the Goals Meeting

Make individual contributions visible: *Teach notes*

Again this idea was rejected by Don. Teach notes or concept maps provide excellent evidence about the quality of the teaching provided by individual students in the Teach Meeting. The notes can be used in the *Reflective Reports*, handed in to the tutor, marked by peers from other groups or put together as a set of notes from each cycle of PBL.

Make individual contributions visible: *Use a self and peer rating form*

Don had success with this approach. He realized that the rating scales needed to have descriptors on each criterion. The form was carefully designed. The student response was very encouraging. As outlined in the Case, many different uses can be made of the data.

An option implicit in this Case involved Maria's assertiveness and her willingness to bring the issue to the group, as described in Part Three. The explicit activity Don should have used was to ask the groups to create their own guidelines about how to handle potential problems *before* they occur. Maria had to do this after the fact. Some options to use before the formal PBL session begin are:

Use commitment charting to initiate the discussion

Commitment charting is a technique where each individual privately notes his/her personal priority and hours willing to devote to this particular PBL activity. Then, within the group this information is shared and used for a discussion and resolution of differences. In this Case, the rest of the group could have heard of and understood Maria's desire to retain her scholarship. They would have discovered that Jason has to balance his school work with a part-time job and that Brad is captain of the basketball team that seems headed for the championship this year.

Use a norms meeting to address the issues

Require each group to have a two-hour "norms" meeting during which the group decides how it will handle such major issues as fair share of the workload and attendance. A listing of 17 major issues is given in the Resources Book (5) and a less structured collection of issues is published (12).

Questions for Personal Reflection

- What have you discovered about working with tutorless groups and how does this affect what you do in the classroom?
- What ideas from this Case apply to tutored groups?
- Don placed much emphasis on the Perry and LASQ inventories. What is your reaction to this type of information? Can it help the groups? Which data might be most helpful in your context?
- Does this Case have any other implications for your own teaching practice?
- If you were writing this Case addressing the issues of tutorless groups and uneven performance, how would it differ? What issues would you emphasize? What main messages would you wish to leave with the reader?

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9. How to evaluate the effectiveness of your PBL course:

Donald R. Woods
McMaster University, Hamilton, Canada
Oct 3, 2002

Case 7: “I liked the course and the students liked it” “

“How did your course go this term?” asked Lim. “I liked it and the students seemed to like it. I guess I won’t change.”

“But was your course cost effective? Was it the most effective learning environment for your students? How well did the students achieve the program goals?” asked the administrator.

An embarrassed silence followed. “Well the students passed the exams, and they were difficult exams this year. And 100% passed the course.”

Case 8: Is it worth it?

This past year the Polytechnic spent over \$500,000 S to help different schools introduce and extent PBL. Is it worth it? Is that how we should be spending our money?

Activity: In small group of 5 or 6, with chair _____;
reporter _____, brainstorm the issues this case raises. Identify what you know already. Identify what you need to learn.

Prioritize the issues: criterion: what do you want to gain from this workshop in the context of the issues raised.

Feedback about the group work. Form **2802**

Task: Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. The accuracy in the group's answer matched the time available. Group avoided contributing excessive information.

None of these behaviours	Few of these behaviours but major omissions	Most features demonstrated	All of these behaviours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	6	7	

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

None of these behaviours	Few of these behaviours but major omissions	Most features demonstrated	All of these behaviours
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	6	7	

Individual Contribution to Task and Morale

Group Strengths

Group Areas to work on

Feedback from the Goals Meeting

Case 7 or 8:

Issues

Number identified: 1 2 3 4 5 6 7 >7

Agreement with tutor <50% 50% 60% 70% 80% 90% 100%

Knowledge/skills to be learned

Consensus among group little some a lot complete

Agreement with tutor's list little some a lot complete

Learning objectives

Quality poor fair OK good excellent

Learning

Quality of questions asked during the teach session none some astute excellent

Willingness to continue to contribute <50% 50% 60% 70% 80% 90% 100%

Your Attitude

Perry shift 2 3 3.5 4 4.5 5

Reflections:

“**Assessment** and Evaluation are judgements made to decide how well goals have been achieved based on measurable criteria and based on evidence”. When we judge the performance of a person, traditionally we call this “assessment”. When we judge the performance of a program, school, company or institution, traditionally we call this “evaluation.” Assess people; evaluate programs.

The same five fundamental principles apply to both assessment and evaluation:

Principle 1. The judgement is based on performance - not personalities.

Principle 2. The judgement is based on evidence - not feelings.

Principle 3. The judgement should be done for a purpose with clearly-defined performance conditions. Before and after? At the end of a series of courses? This year versus last year?

Principle 4. The judgement done in the context of published goals, measurable criteria and pertinent, agreed-upon forms of evidence.

Principle 5. The judgement should be based on multidimensional evidence.

For example, in Canada, Maclean’s magazine annually evaluates universities. The forms of evidence they use include: about the students: the average entering grade of the students, the proportion who have marks higher than 75%, the proportion of students entering who graduate, the number of “out of province” students in the undergraduate program, the number of foreign students in the graduate program, and the number of awards received by students. For classes: the class size, and the number of classes taught by tenured faculty. For the faculty: number of professors with PhD’s, awards per full time faculty member; amount of research grant funding received. For the budget: operating budget, the % of the budget that goes to scholarships and bursaries and the % of the budget that goes to students services. For the library, the total holdings, the holdings per student, the acquisitions and the expenses. For reputation: alumni support and survey of major industries and institutions about the reputation.

Following Principle 3, we should evaluate programs to continually improve the learning effectiveness and to help us decide on priorities and funding.

1. Evaluation to monitor a course while it is in progress

We should use methods to give us feedback *while the course is in progress*. I think this should be done in every course, but especially in PBL courses where the students perceive the learning environment to be different than expected.

We can monitor our courses by:

- class ombudspersons
- one minute papers
- any of the methods suggested by Angelo and Cross “Classroom assessment techniques”

Jossey Bass.

This allows us to make mid-course adjustments and to show students that we really believe that teaching and learning is a combined effort.

Action:

Which approach will you take?

2. Evaluation of the overall effectiveness of a course

Many teachers do not take time to evaluate the overall effectiveness of their courses. Unfortunately, when it comes to teaching many professor “diddle around”. They try one thing in the classroom; then they try another. Their approach evolves like Topsy with them never sure as to what works and what doesn't. They would never do research in our subject discipline that way. In subject-discipline "research" they create a hypothesis, create models or experiments and test the hypothesis and draw conclusions. With just a little more effort, we can bring that same scholarship to teaching. The hypothesis is that “by making a change in how you teach your students will learn more effectively and/or they will develop process skills of value to them as professionals.” Your intervention should make a measurable change. Reflect on what went on. Keep your own learning journal. Gather evidence. Write journal articles and seek grants. Being scholarly in your approach means that right from the start you plan how to test and monitor the effectiveness of what you do.

How might you gather evidence?

- We can use data about student performance as a measure (for any course):
 - % who passed the course;
 - quality of the exam (degree of difficulty, number of questions requiring higher level Bloom performance, fairness [or relationship between the published course objectives and the exam questions; the time it takes a professor to write the exam compared with the time allowed for the student {should be in the range 1:2 to 1:4}].
 - student mark improvement from entry to exit.
 - number of scholarships or awards your students receive.
 - feedback about student performance from instructors in subsequent courses.

- We can gather data about the development of deep learning instead of surface learning (for any course):
 - use Course Perceptions Questionnaire, CPQ (about the quality of the learning environment).
 - use pre and post Lancaster Approaches to Studying Questionnaire, LASQ.

- We can use the Peer Evaluation of Educational Programs inventory whereby peer faculty evaluate the planning that went into the course (for any course).

- We can measure changes in “processing skills” such as problem solving, team work, self assessment, lifelong learning, change management, communication (especially for PBL courses). Many well-developed instruments can be used for Pre and Post tests.

Consider using some simple and easy-to-administer pretests and post-tests. Examples for process skills have been cited (Woods, 1999e; Woods et al., 2000b, Woods et al., 1997). Download some from <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL and download E.

Perry Inventory,
 Heppner’s inventory,
 Billings Moos
 Basadur creativity

- Gather data from exit surveys. Queen’s University has developed an excellent survey (Queen’s, 1994) (for any program).

Action:

Which approaches are you using or will you take?

3. Example

Example: for McMaster’s chemical engineering program: MPS and PBL program see <http://www.chemeng.mcmaster.ca/innov1.htm> & click on MPS and PBL

The program: The program consists of four required courses:

2 nd year: 48 tutorial hrs. required	PS homewk.
3 rd year: about 20 hrs. required for application	PS
3 rd year: 45 tutorial hrs. required	teams; PBL
4 th year: 30 h. required	PS, team, PBL

Our published outcomes for the program: problem solving, team, self assessment, lifelong learning.

Constraint: can’t continually add new courses & still have 4 year program
 give more fish -> teach to fish

MPS (four courses) 20% of total curriculum

PBL component: “safety” engineering economics” “process operability” 2% of total curriculum.

Develop process skills **before** PBL. 6 - 10 groups & 1 teacher: tutorless groups

Program evaluation:

- Marks improve in other courses compared with control
- Course Perceptions Questionnaire: 28 to 35 compared with 15 to 20 with control
- Confidence in PS skills: 90 -> 70
control 90 -> 85
- Skill in PS: Billings-Moos
- Attitude toward lifelong learning: Perry; Deep learning
- Self assessment skill
- Alumni & recruiters surveys and responses.

Enrichment:

1. Please help me understand how best to help you
2. MRIQ
3. Inventories and scoring
CPQ
LASQ
Heppner
Billings Moos
4. Exit Questionnaire

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The Learning Experience

1 The following statements are concerned with your learning experience at Queen's. Think back to your experiences as a student at Queen's and indicate how much you agree or disagree with each statement by circling one of the numbers at the right.

	Strongly Disagree					Strongly Agree
a	1	2	3	4	5	
b	1	2	3	4	5	
c	1	2	3	4	5	
d	1	2	3	4	5	
e	1	2	3	4	5	
f	1	2	3	4	5	
g	1	2	3	4	5	
h	1	2	3	4	5	
i	1	2	3	4	5	
j	1	2	3	4	5	
k	1	2	3	4	5	
l	1	2	3	4	5	
m	1	2	3	4	5	
n	1	2	3	4	5	

1b Which three of the statements listed above, in order of importance, were most important to you? Please circle the letter corresponding to the statements listed above. (Circle one letter only for each rating.)

Most important	a	b	c	d	e	f	g	h	i	j	k	l	m	n
Second most important	a	b	c	d	e	f	g	h	i	j	k	l	m	n
Third most important	a	b	c	d	e	f	g	h	i	j	k	l	m	n

2 Please indicate the degree to which your education (both inside and outside the classroom) at Queen's contributed to your learning and development in each of the following areas?

	Very Little				A Great Deal
a	1	2	3	4	5
b	1	2	3	4	5
c	1	2	3	4	5
d	1	2	3	4	5
e	1	2	3	4	5
f	1	2	3	4	5
g	1	2	3	4	5
h	1	2	3	4	5
i	1	2	3	4	5
j	1	2	3	4	5
k	1	2	3	4	5
l	1	2	3	4	5
m	1	2	3	4	5
n	1	2	3	4	5
o	1	2	3	4	5
p	1	2	3	4	5
q	1	2	3	4	5
r	1	2	3	4	5
s	1	2	3	4	5
t	1	2	3	4	5
u	1	2	3	4	5
v	1	2	3	4	5

2b From the above list, please indicate in order of importance the three areas which were most valuable in contributing to your learning and development.

Please circle the letter corresponding to the factors listed above. (Circle one letter only for each rating.)

- Most important a b c d e f g h i j k l m n o p q r s t u v
- Second most important a b c d e f g h i j k l m n o p q r s t u v
- Third most important a b c d e f g h i j k l m n o p q r s t u v

10. Myths and misconceptions about PBL

Many myths and misconceptions have developed about PBL. Probably the most prevalent one I hear is “How can students solve a problem if I haven’t given them a lecture on the background knowledge?” Other issues include I’m doing PBL already, there is only authentic version for PBL, isn’t there a dilution of content? PBL can only be used for certain disciplines, my students cannot do PBL, all students will love it, it’s easy for teachers to use it, and by using PBL you’re giving students licence to study whatever they want. What’s happening to standards? Consider each in turn.

10.1. Myth? Prior subject knowledge is needed before students can solve PBL problems

Problems can be used for several purposes. Students - and teachers - are used to assigning problems from the *end of the chapter* or *after a teacher has lectured*. Such problems are used in the context of.. this is the knowledge you need to know, I have given you the basic ideas

- Use problems after they know stuff; synthesize knowledge.
- Use problems to drive the search for knowledge (student ownership; solving in the context of professionals; learned in the context of future need)

Myth? is this possible? Biggest leap!

Yes... you have done this many time.. been confronted with a problem, had to figure out the issues, called people, learned stuff and solved it. The hardest hit when you let students do this is your ego.. you are no longer the source of all information.

Yes, all MDs from Mac since 1972; ChE from Mac since 1982

Mac: Nurses, OT/PT

MD, U New Mexico, Newcastle U, Maastricht U.

Delaware: Samford, Temasek

10.2 Myth? I doing PBL already

Many think because they are using problems, then they must be doing problem based learning. “Don’t students really learn the stuff I lectured on when they are doing the homework problems at the end of the chapter?” Yes. That’s probably true that students learn when they are doing the homework; that they didn’t pick up much knowledge from lectures. However, assigning problems is not PBL.

10.3 Myth? there is only one form of PBL

Luis Branda, a colleague from McMaster, used PBL effectively in his class of 120 with one instructor. His unique version of individual, self-directed, teacher assessed, independent PBL. In this context students given a problem and identified what they needed to know to solve the problem. Each individual created his/ her learning objectives, researched to locate and learn the

new knowledge. They summarized that knowledge for himself/herself. Branda provided each person with examination questions on each person's learning objectives. He marked it. Is this PBL. Certainly!

Jim Harvey, a fictional colleague, gave a group of students a design problem to do in their senior year. The project required them to draw on all the courses they had taken, to identify any new knowledge they needed and then to solve the design problem. Is this PBL? Partly. This approach lacks structure. Students are not formally asked to (or marked on) identify the new learning that is required. The students don't usually share or teach each other the new information. Usually people in the group are responsible for different tasks and there is no expectation that everyone is responsible for learning the new knowledge. The amount of new knowledge varies with the project and the previous courses that were taken. For projects with reactors, heat exchangers and distillation columns (subjects that most chemical engineering students know already) then there is relatively no new knowledge needed. Is this PBL? Definitely not; usually this is problem synthesis.

Here we consider the key characteristics of PBL and describe some options where PBL has been used.

10.3-1 PBL: What are the key characteristics of small group, self-directed, self-assessed, interdependent PBL?

- an extremely effective way to improve student learning. Other methods OK too, but PBL uses the most of the proven ways.
- method that develops "Deep learning" not "Rote learning". Straight lecture promotes "Rote learning" whereas the use of small group, self-directed, self-assessed PBL develops deep learning.
- develops skills needed in your student's career especially *Lifelong learning*. Others too: problem solving, group work, critical thinking. but these can also be developed by methods other than PBL.

1. Presentation of knowledge on a "need to know" basis instead of "trust me, you'll need this stuff sometime."
2. Pose the problem first.
3. Empower students with most, if not all, of the elements of the learning process: scrutinize a situation, identify new knowledge needed to address the situation, create learning objectives, identify key resources, critique the resources, learn and teach each other, assess the integrated set of knowledge the group learned, apply it to solve the problem, assess the knowledge and skills developed, elaborate the knowledge to put it into context and see where else you can use the knowledge.
4. No "lecturing" by students or by teacher unless requested with clear learning objectives given by the students and requested by the students.

Any form that includes all four of these characteristics is what I would call authentic PBL. Some

versions that maintain four characteristics include:

- Socratic version where small groups are present in the room; the teacher tutor facilitates occasionally. This is described in “PBL: helping your students gain the most from PBL”; downloadable from <http://www.chemeng.mcmaster.ca/innov1.htm> and click on PBL. example MD program at U of Adelaide, Australia.
- Using Branda’s approach with individual, self-directed PBL; described in “PBL: Resources to gain the most from PBL”. example, Luis Branda’s course in biology.
- Using extensive pretraining and autonomous student groups; example, Chem. Eng at McMaster.
- Using a tutor with each group; example MD, Nursing, Physio and occupational therapy at McMaster.

10.1-2 Myth? There is only one authentic form of PBL

The popularity of PBL has spread so rapidly and extensively that a) many don’t really know the fundamental underpinnings of PBL, b) they think that all you do is pose a problem and turn students loose. This sloppy implementation of “something” in the name of PBL has provided a backlash from those who are indeed trying to use small group, self-directed, self assessed, interdependent PBL who suggest that there is one form of “authentic” PBL. Incorrect, there is a lot of flexibility in implementing a range of options that satisfy the fundamentals. Here are some:

- a) use Individual, self directed PBL (the assessment component and small group (cooperative element) are missing), but this is a very exciting and, in my view, valid way to use PBL.
- b) use small group (size 5 to 8 max), self-directed, PBL (assessment component and interdependent elements are missing). Here the teaching element is minimized, students report their research, more than one student may be “studying the same topic” or indeed all might be studying the same topics and the “teach meeting” is a critique of the information.
- c) small group, self-directed, self-assessed interdependent PBL with a tutor in each group.
- d) small group, self-directed, self-assessed interdependent PBL without a tutor in each group.

There might be a tutor-facilitator for two to 50 groups of five students; alternatively, the students may function as empowered autonomous groups.

10.3 Myth? Dilution of Content

Dilution... Reduction of subject knowledge? Yes. In a fixed three or four year curriculum there are only so many hours available per course. In the conventional courses this is 120 h, for class activities, self study, homework, studying for tests/exams and doing the exams. PBL is a learning environment that draws on students problem solving, group, self assessment, goal setting abilities. It provides an opportunity to develop these skills further. Recall that effective teams spend 25% of their meeting time on “process activities” and 75% of the time actually solving the problem that they were given to solve (Reddy, W.B. 1994, “Intervention skills: process consultation for small groups and teams, Pfeiffer & Company). So it is not surprising that the subject knowledge that can be mastered is about 75% of the knowledge that is “covered” in a conventional lecture environment. You note, I do not use the term mastered in the conventional lecture environment.

This really is not a problem because:

1. in preparing to use PBL we know that the amount of topics “covered” needs to be reduced. We identify the fundamentals; ensure these are embraced in the PBL experience. The other frill topics students can learn on their own when they need to know it. Since we introduced PBL, no alumni, no company has ever said that graduates of our program “didn’t know the fundamentals”. Instead they have said, “your graduates are ready to work as soon as I employ them; graduates from other schools require about 2 years of training.”
2. graduates with have the fundamentals **plus** skill in lifelong learning, and usually skill in problem solving, listening, communication, locating and assessing information, self awareness and team skills.

To help you identify the fundamentals in your discipline you might ask the question: In the year 2020 do the students need to know “everything” you lecture about now?

Focus on the core fundamentals of your discipline = 50 to 70% of what you currently “cover” in class.

How important to you are the task of developing:

- problem solving,
- team work,
- change management,
- communication,
- lifelong learning.

10.4 Myth? My Students cannot do PBL

If they think so & you think so.. then you are right.

Attitude shifts for both students & you

Prepare them

10.5. Myth? PBL can only be used for certain disciplines

So far PBL has been used successfully in

Medicine

Nursing

Pharmacy

OT/ PT

Dentistry Queensland

Business Temasek, Samford, George Brown, Seneca

Engineering Monash, Manchester, McMaster, Oxford Brookes

Science Delaware, LaTrobe

Law Calgary, Wollongong

Architecture Newcastle, Adelaide

Teacher training

Vet Medicine Guelph
IT Linkoping, Seneca
Police NSW, Queensland

10.7. Myth? It's easy for teachers to use it

It is not easy. It requires a major attitude shift: you are no longer the sage on the stage, you are the guide on the side. A shift that students can actually learn and teach each other instead of I have to tell them my knowledge. A shift that they can self assess.

Next, implementing PBL requires a lot of work. You need to create the problems and pretest them to ensure that the cues are well-designed. You need to gather the resources they will need so that a new subject can be located and learned in about 2 h per student per week.

10.8. Myth? All students will love it.

Not all students will love it. Some will struggle.

10.9 Myth? you're giving students licence to study whatever they want. What's happening to standards?

The students are not given licence to study whatever they want. The problems are crafted so that the students will create *your learning objectives* for your course. The difference is that the students feel ownership for the objectives and for the learning.

Self assessment journals

Marking/feedback on self assessment journals for process skills

Chairperson skills
Lifelong learning skills
Trouble shooting/clinical skills

Examples:

PBL Deirdre Schroder
PBL Fahim Ahmed
Chairperson Kathryn Grundy

Feedback on Chairperson self assessment journal

name _____

Group number: _____

/30

Analysis:

Numerical summary of Task
and Morale scores:

chair's role: + x 2; neutral x 1; negative x -1 and total: 5/30

Listing of strengths & areas to work on: 5/30

Arithmetic average of "satisfaction with decision" 3/30

Anecdotal summary of events and comments (and about growth in subsequent meetings) 6/30

Quality of the agenda: 4/30

Relate evidence to goals and achievement of goals: 5/30

Overall communication: 2/30

/30 **Feedback on First PBL self assessment journal on lifelong learning skills**

Name _____

attitude and risk: 5

understanding of interdependent learning, Perry attitude and shifts for you and for group that have occurred or that you might have to address; [form p 105, p. 106]
include checklist of attitudes [form 3600, p 109] 2

overall plan and strategy: 10

have one?
skill in identifying learning issues: [form 106]
include learning contract or equivalent if you generated one
Quality of the teach notes:
Quality of "test question" and answer :

analysis: 10 relate to learning objectives of MPS 36 [p. 103]

summary table of numerical values of communication, knowledge & feedback for this meeting:
(form p. 119 to 142 using scale of 8)
table of comments about strengths
table of comments about weaknesses
include all feedback sheets from all members including self:
comment on group and learning style, attitude: [form p 105]
help us understand what really happened in your meeting:
is PBL working for you and for your group?

communication: 5

If the memo only is marked, the marking will be based on how well all of the issues were summarized in the memo

A120

Feedback on PBL

Name _____

attitude and risk: 5

understanding of interdependent learning, Perry attitude and shifts for you and for group that have occurred or that you might have to address; [form p 105, p. 106]
include checklist of attitudes [form 3600, p 109] 2

overall plan and strategy: 10

have one? 2
address learning issues: 1
 list of topics generated?
 explore issues? resource? learning objectives?
feedback checklist included: 3
include learning contract or equivalent: 2
include teach notes: 1
include "test questions": 1

analysis: 10 relate to learning objectives of MPS 36 [p. 103]

summary table of numerical values of communication, knowledge & feedback for this meeting:
 (form p. 119 to 142 using scale of 8)
table of comments about strengths
table of comments about weaknesses
include all feedback sheets from all members including self:
comment on group and learning style, attitude: [form p 105]
help us understand what really happened in your meeting:
is PBL working for you and for your group?

improvement: 10

summary table of numerical values of communication, knowledge & feedback for all meetings:
maintain strengths:
 table of comments
 note and discuss
shift one weakness:
 table of comments
 note

communication: 5

Forms: p 105, 106, 109, five or six from 119 to 142

If the memo only is marked, the marking will be based on how well all of the issues were summarized in the memo

Feedback on Trouble Shooting self assessment journal

name _____

/150

process: 40

evidence of:

organized approach: (objective 3.1: evidence observer form/reflections)

monitoring: (objective 3.2: evidence observer form/ reflections)

hypotheses: (objective 4.1, 5.1; evidence observer forms, notes)

data analysis: (objective 4.2, 4.3; evidence observer forms, notes)

select an appropriate approach: (objective 3.4, evidence observer forms, notes)

clarity of questions written out (objectives: 3.3; 5.2; evidence observer form;

green sheets)

improvement: 25

maintain strengths: 9/25

note and comments

shift one weakness: 12/25

note and comments

Overall 4/25

analysis of the triad: 30

what did you learn from playing each role?

how did this vary from case and triad to triad:

what did you learn about trouble shooting from interacting with others

communication: 10

relate evidence to learning objectives: 35

skill in self assessment 20

evidence to back up claims or just wishful thinking?

Forms: Learning objectives, 145

Written evidence sheets from role as TS, 171 ff

Feedback from observer, p 149

Reflections:

Papers used to make notes during the activity

220,5.5

A-6

To: Dr. D.R. Woods

From: Deirdre Schroder *D. Schroder* 11/15/05

Date: November 15, 2005

Topic: Self Directed/ Problem Based Learning Report #3

Attitude and Risk:

My Perry number is now 4.0 despite the fact that I didn't think it would change from the 3.6 it was before. The Perry numbers of the other members in my group are mostly in the 3 to 4 range and I think we are back on the upswing with the Perry indicator in the third cycle. We still need to work on increasing our group Perry scale towards assessment. I am still receiving feedback where only positive comments are given.

The checklist of attitudes is attached. I have increased my confidence in the group's ability to assess learning needs realistically, and this has helped me increase my Perry number. In addition, my lowest progress point is now at the 80% mark. I have become more dependent on my group members for learning because the material in PBL 3 was not covered in my previous management classes. The attitudes of others in my group I believe to be increasing although I still feel as though some people tend to 'skip' the difficult topics and hope these items won't come up in the assess meeting.

Overall Plan and Strategy:

My overall plan for the Problem Based Learning portion of the course is unchanged and remains to improve on my areas of weakness and to help others overcome their weakness by using my strengths.

I feel our group is improving in our willingness to contribute. People are putting forth larger effort in their teach notes and are providing more feedback in chairperson and teach forms. Form 106 is attached. We correctly identified 100% of the relevant tasks.

Copies of my notes for teaching as well as the handout provided to the other group members are attached. I used a mix of teaching styles to accommodate the range of learning styles in our group. I provided a chart outlining each element of my discussion and typical values. An example was provided but as the feedback shows, the lesson was still too complicated and one person felt as if they would require a fair amount of follow-up (score: 5/8) in order to understand the topic.

My 10 minute test question and answer were not selected to present to another group. I was not overly enthused about our choice of question. We have received poor marks on two out of three of our chosen assess questions now and I will make sure to express my concern in PBL 4. If I feel that my question is the best I will try not to shy away and instead push for my question to be selected.

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Analysis:

Given the following proof, I feel I have completed the following objectives from page 103 MPS 36 between 90-100%: 1.1, 2.1, 2.2, 3.1, 3.2, 3.3, 3.4, 5.1, 6.1, 6.2, 5.3. ✓
 I have not made any improvement on goals 3.5 and 6.3. Goal 5.2 is partially completed.
 I have turned my weakness in regards to time management into a strength, however, I have developed a weakness of being too complicated. During PBL 4 Teach meeting I will try to improve in this area.

Excellent

Table 1: Teach Feedback Average Scores for Deirdre

Criteria	PBL 1	PBL 2	PBL 3
Quality of Knowledge	7.4	7.5	7.6
Quality of instruction	7.6	7.5	7.4
Follow-up	7.2	7.25	6.8

✓ *Thank you.*

Table 2: Summary of Comments

PBL 1		PBL 2		PBL 3	
Strengths	Weaknesses	Strengths	Weaknesses	Strengths	Weaknesses
Good understanding	Time Management	Good Handout	A little confusing	Clear Voice	Difficult to follow
Interactive		Good understanding		Awesome Handout	
Clear explanation		Good spreadsheet		Good understanding	
Good instruction		Clear explanation		Good attitude	
Loud and clear		Loud and clear		Timely	
Positive		Positive		Organized	
Well presented		Time management		Confident	
Good Handout		Good speaker			
Good speaker					

Very good. Easy to see program.

The teach meeting went even better than the first two. Students were excited about their newly acquired knowledge and eager to share it. The quality of the information shared increased as well. It was clear that people put much more effort into their teach notes for PBL #3. Our assess meeting went fairly well. We answered our assigned question well but I was not happy with our selection of assess question, as mentioned above. ✓

Improvement:

I think PBL is beginning to work for our group. Progress is definitely being made.

Personally I have improved in my attitudes, my Perry score, and in completing the PBL objectives. My teach feedback was fairly consistent although I have not improved in making my teaching less complicated for one group member. As Table 1 indicates, I have maintained all my strengths from the previous 2 PBL reports. I have also maintained the weakness of time management in PBL 1 to a strength and maintained it through PBL 2 and 3. My next step is to shift the weakness of being too complex in my teaching to a strength for PBL 4. ✓

As a group we have become better at identifying relevant issues in the problem and have become more aware of each other's learning styles. As mentioned above, the teach notes provided by the group have improved in quality and quantity. (By quantity I am referring to the fact that one member did not provide a handout in PBL 1 and others provided too much information.) The group is also improving in terms of starting and finishing the meeting on time. ✓

Communication:

I have attached all the relevant documentation for this report: forms p 106, 109, six feedback forms, assess question and answer, and teach notes. In addition, I have attached my Perry assessment sheet for your review. It shows my progression over the first 3 PBL reports and may be useful in your research. ✓

Excellent

A-9
36-6

Situation C6

Issues

Number identified: 1 2 3 4 5 6 7

Agreement with tutor <50% 50% 60% 70% 80% 90% >7

Knowledge/skills to be learned little some a lot complete

Consensus among group little some a lot complete

Agreement with tutor's list little some a lot complete

Learning objectives Quality poor fair OK good excellent

Learning Quality of questions asked during the teach session none some astute excellent

Willingness to continue to contribute <50% 50% 60% 70% 80% 90% 100%

Your Attitude

Perry shift 2 3 3.5 → 4 4.5 5 ✓

← assumed since the goals meeting was cut short & issues were assigned by Dr. Woods.

* up from "some" in PBL 2

* up from 70% for PBL 2.

● Able to shift from being a dependent learner through being an independent learner to being an interdependent learner.					✓			☁	
● Able to devise a time plan and stick to it reasonably well.					✓			☑	☁
● Willing to assume responsibility and ownership for the tasks in learning: (goal setting, resource identification, learning, assessment).								✓	☁
● Meets contract commitments to teach others.									✓
● When teaching others, uses the principles of learning and addresses differences in learning styles (instead of "reporting information" and expecting the learner to sort it out).								✓	☁
● When learning a "difficult" topic, willing to accept the challenge to unravel the complexity (instead of skipping over it and "hoping it won't be on the exam").						✓		☑	☁

✓ - PBL #1
☑ - PBL #2
☁ - PBL #3

A-10

36-19

Fig 36-1: Feedback to Deirdre for Unit 3
on the Learning components Date Nov 1

Present & on time: Present but late by _____ min.

All members of our group present except for _____

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input checked="" type="radio"/> 7	<input type="radio"/> 8

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input checked="" type="radio"/> 7	<input type="radio"/> 8

Followup: from this presentation I will have to:

<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>					
-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	----------------------------------	-----------------------

study the subject on my own; I learned nothing from the presentation

practice on some problems; however, I have all the fundamentals I need to know.

Strengths timely
organized

Areas to Improve on

A-11

36-19

Fig 36-1: Feedback to De for Unit _____

on the Learning components Date Nov 1/05

Present & on time; Present but late by _____ min.

All members of our group present except for _____

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Followup: from this presentation I will have to:

<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6	<input checked="" type="radio"/> 7	<input type="radio"/> 8
-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	------------------------------------	-------------------------

study the subject on my own; I learned nothing from the presentation

practice on some problems; however, I have all the fundamentals I need to know.

Strengths

- knowledgeable
- confident
- I liked the candy

Areas to Improve on

A-12

36-19

Fig 36-1: Feedback to Dee for Unit Ass Teach 3

on the Learning components Date Nov 1
Present & on time: Present but late by: _____ min.

All members of our group present except for _____

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these	A few but major omissions		Most of these		All of these
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
1	2	3	4	5	6
					7
					8

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these	A few but major omissions		Most of these		All of these
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
1	2	3	4	5	6
					7
					8

Followup: from this presentation I will have to:

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
-----------------------	-----------------------	-----------------------	-----------------------	----------------------------------	-----------------------	-----------------------	-----------------------

study the subject on my own; I learned nothing from the presentation

practice on some problems; however, I have all the fundamentals I need to know.

Strengths

good speaker
loud
clear

Areas to Improve on

found it difficult to follow what you said.

Fig 36-1: Feedback to DEIDRE for Unit #6

on the Learning components Date NOV 1/05

Present & on time: Present but late by _____ min.

All members of our group present except for N/A

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Followup: from this presentation I will have to:

<input type="radio"/>	<input checked="" type="radio"/>						
-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	----------------------------------

study the subject on my own; I learned nothing from the presentation

practice on some problems; however, I have all the fundamentals I need to know.

Strengths

- Good HANDOUT
- POSITIVE
- GOOD KNOWLEDGE
-
-
-

Areas to Improve on

A-14

36-19

Fig 36-1: Feedback to Dee for Unit Teach 3
on the Learning components Date Nov 1
Present & on time: Present but late by _____ min.
All members of our group present except for _____

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Followup: from this presentation I will have to:

<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>					
-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	----------------------------------	-----------------------

study the subject on my own; I learned nothing from the presentation

practice on some problems; however, I have all the fundamentals I need to know.

Strengths

Clear voice
Awesome handout
knew topic
good ~~attitude~~ attitude

Areas to Improve on

None

Fig 36-1: Feedback to Self for Unit 3

on the Learning components Date Nov 1, 2005

Present & on time Present but late by _____ min.

All members of our group present except for _____

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these	A few but major omissions		Most of these	All of these
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
1	2	3	4	5
				6
				<u>7</u>
				8

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these	A few but major omissions		Most of these	All of these
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
1	2	3	4	5
				6
				<u>7</u>
				8

Followup: from this presentation I will have to:

<u>0</u>							
1	2	3	4	5	6	7	8

study the subject on my own; I learned nothing from the presentation

practice on some problems; however, I have all the fundamentals I need to know.

Strengths

loud
hard
fast
knowledgeable

Areas to Improve on

Teach 3
11/01/05
Deirdre Schroder

TOPIC: PROJECT COSTS FROM 1. FOB TO 5. L+M MODULE COST

This set of costs corrects the free-on-board cost by multiplying it by a factor in order to take into account the cost of materials, labour, and building preparation work.

Table 1 summarizes the inclusions, exclusions and typical values for each of the costing elements.

The L+M Module cost also takes into account the instrumentation cost but this is independent of the FOB cost. Three methods exist to estimate the instrumentation cost: average cost per main plant item (MPI), control element cost per MPI, and instrumentation cost per equipment type.

1) Average cost per MPI

- Uses the type of plant (typical process plant, highly automated plant etc.) to determine the average cost. See table 15-15.

2) Costing the control system for an MPI

- Uses the type of process (batch, semi-batch, continuous, etc.) to determine the average cost. See table 15-14.

3) Costing for particular types of equipment

- Based on the number of control loops, alarms, and transmitters per piece of equipment. See table 15-15.

EXAMPLE

CENTRIFUGE	Total	Labour, L	Material, m
FOB	1.00		
Setting		0.101	
Piping		0.109	0.25
Insulation		0.024	0.04
Paint		0.01	0.01
Erect		0.122	0.27
Concrete		0.038	0.09
Steel		0.049	0.1
L+M*	2.21	0.453	0.76
L/M	0.26		

ref: handout provided by Dr. DE. Woods
"Estimation of the fixed and total capital investment"

ESTIMATION OF THE FIXED ABD TOTAL CAPITAL INVESTMENT**Question:**

You are working on the conceptual design of a continuous process. The prototype BM cost was \$25,000 (CE 370 = today's value). Surprisingly, there were no offsite or indirect costs and the tax, duty, freight and insurance fees were negligible compared to the cost of the equipment. The instruments cost \$1000 (CE 1000) and no building modifications were undertaken to accommodate this project. The prototype had a flow rate of 45 LPM and needs to be scaled up to 99LPM. Also, in order to cut costs, you boss has said that 304 stainless steel (food grade) can replace the 316L stainless steel (medical grade) that the prototype was made from. This changes the original alloy factor of 2.8 to an alloy factor of 2.1. The new equipment is to be purchased and installed one year from now and the inflation rate is 3%.

What are the L+M module cost, the $L+M^*_{\text{alloy}}$ cost, the new L+M* ratio divided by the old L+M* ratio, the required n value for the project, the inflation cost, and the final project cost estimation?

A-18
36-14

09/08/05

Table 2-9b: Example inventory to help you identify your learning preference: adapted from Moore and Fitch, 1988

code	My Ideal learning environment:
15	would be where learning is a mutual experience where I contribute to the teaching and learning in class.
12	would have the focus on having the right answers rather than on discussing methods on how to solve problems.
45	would value my classmates as sources of information, not only as companions.
14	would reward me with high grades for independent thought.
82	would be where the professor provides me with clear directions and guidance for all course activities and assignments.
65	would take learning seriously and be where I feel personally motivated to learn the subject.
33	would reward me with good grades when I worked hard to learn the material.
55	would provide me with a professor who is a source of expertise only in a particular subject area.
54	would let me learn from my classmates and peers.
35	would provide a classroom atmosphere of exploring and debating new ideas.
43	would encourage me to learn using lots of different learning methods.
84	would allow peers the right to have their own opinions.
25	would include exams and assessment as part of the learning process.
62	would be lectures since I can get the information I need to know most efficiently.
23	would have a professor who was not just an instructor, but more an explainer, entertainer and friend.
34	would be a "free-flowing" class that does not follow a strict outline.
85	would provide a workshop or seminar atmosphere so that we can exchange ideas and evaluate our own perspectives on the subject matter.
93	would provide a relaxed atmosphere where discussion is encouraged.
32	would be where I could listen intently to the professor and not to classmates and peers for answers to questions.
75	would be where I can make connections among various subject areas and am encouraged to construct an adequate argument.

Adapted from Learning Environment Preferences scale by W.S. Moore copyright 1987 and Peggy Fitch copyright 1988.

Peiry
Moore Fitch Learning Environment Preference

Each of us has an ideal learning environment. Think of how you learn best. Try not to focus on one particular course or one particular instructor. Focus on their significance in an ideal learning environment for you.

You have 10 check marks to distribute among 34 questions. Put a check mark in the * column next to the statement that best describes your ideal learning environment. The code column is for easy reference when we discuss the inventory.

code	My Ideal learning environment:
63	would provide assignments with practical everyday applications.
22	would have the professor give me all the theory and information I need to know.
74	would be where I would have a lot of control over the course content and class discussion.
72	would be where I take effective notes on what is presented in class and reproduce that information on tests.
13	would emphasize class discussion but I would expect the professor to tell us the right answer.
24	would be where I have my own opinions and I can think for myself.
53	include grading that is by a prearranged point system (for homework, tests, final) since I think that is most fair.
42	would include straightforward, not "tricky" tests, covering only what has been taught and nothing else.
64	would let me learn on my own because I hate being spooned by professors.
73	would be where the professor doesn't tell me the answers; rather he/she shows me how to find the answers for myself.
95	would provide a flexible class where I can explore independent learning options.
44	is where my opinion counts, but I have to support it with factual evidence.
52	would be where the professor is an expert who knows all the answers.
83	would provide experiences and material that is relevant to what I need to know later.

(over)

FINAL PEARY
PBL #3
3.6 → 4.0

PBL #1
3.4
5
= 3.4

3.4 → 3.6

1 2 3 4 5 6 7 8 9 10
1 2 3 4 5 6 7 8 9 10

A-19



From: Fahim Ahmed

To: Training Office Dr. Woods
17th November 2005

Re: PBL Session Three, Report

This memo is to confirm the completion of PBL session three, in which, the problem state was Case 6 of MPS-Unit 36. The objectives were the same as before, solving the problem by conducting a Goals', Teach and Assess meeting each. This would help us enhance our skills on a personal level, in-group and convert a previous weakness to a strength.

I personally did not attend the extended after class goals meeting, but to my knowledge, the problem was explored by the members of the group and the group came up eight different Goals and this was agreed as 90% of the suggested Goals, by the tutor. The contents of the eight goals were different in magnitude, and therefore it was split according to size and was to be taught by one of the group members in the Teach meeting.

The teach meeting was a smooth affair, where things were wrapped up in good time. The group performed a semi-online teach meeting, where the teach notes were email to each other, and then a small meeting discussed issued that each member had from the teach notes. I realized as each PBL session goes by, it becomes easier to explain a problem, based on numerical values, over one that does not use them. Finally, the Teach feedback forms were obtained and the results are tabulated in comparison to the result of the previous PBL session, and displayed my improvement over the one PBL session. The reason the Quality of Knowledge portion dropped points, I believe, is because the initial teach notes were electronic instead of hardcopy, I have come to learn that this is an important factor for meetings, where agendas are better received on hard copy than soft ones.

	PBL 2	PBL 3
Quality of Knowledge	8	7.8
Quality of Instructions	7.8	8
Followup	7.8	8

In the assess meeting, I devised another question, that was up for selection, but I declined the offer, to go three times in a row, where there was a group of five members. My question and answer are hereby attached to this report. The foreign question was then received and answered, with perfect results, while the question we proposed was well received and was given perfect marks for. There were no setbacks in answering the foreign question, and the job was efficiently split amongst two and three group members and completed.

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A-20

Following is the list of PBL objectives that are up for assessment, the objectives are tabulated and a personal score assigned to each objective to display personal development of shift over the three PBL sessions:

Objective:	Comment	Score Shift
1.1 Concepts Introduced	The taught concepts were all well defined and explained, and as shown in the handouts, were explained with an example	6 - 9.5
2.1, 2.2 Goals	There were eight Goals identified, with the tutor agreeing with 90% of the objectives. This goal was somewhat completed	5 - 9
3.1, 3.2 Learning Objectives And Method of Assessment	The topics were divided and learnt, and then taught in the teach meeting, the scores from the Teach Feedback display the improvement	7 - 10
3.3 Assess Question	The question was prepared, and accepted by all members, but was not used, because I had gone the last two times	9 - 10
3.4 Questions	The teach notes were identified and specific questions were asked Where and when anything or any idea was not understood.	8 - 10
3.5 Reflections	Reflections were not written once every ten minutes, but personal Reflections were written as done before.	7 - 10
5.1 Teach notes and Topics	Explained in the above paragraph in depth, and the scored have increased on average.	9 - 10
5.2 Weakness to Strength	Explained after this table	9 - 10
5.3 Brainstorming	The brainstorming sessions for the questions generate 5 to 7 ideas every time instead of the minimum thirteen	5 - 6
6.1 Assess	The question given was answered swiftly and perfect marks were Obtained	9 - 10
6.2 Perry Shift	From the first PBL the Perry's Number has shifted and has now reached 4.5/5 on a personal level and 4.75/5 on a group level. Somehow, the group members seem function better with the group than amongst themselves.	9
6.3 Learning Journal	The PBL reports have become written journals of our achievements	10

As displayed in the table above, every objective was completed, learnt and assessed. The only shallow area, where improvement is required, is area 5.3, where the bias on ideas, tends to reduce the number of brainstorming ideas.

The weakness that has persisted, and unfortunately still persists is the pace at which I run the meeting/teach meeting. The same person, as I observed from the handwriting, always pointed out this slight weakness. For the fourth PBL Session, I have taken extreme care as to illustrate the problem in a much easier pace than before. The weakness that was changed to a strength was defining terms. The terms in the teach notes were verbally defined as it is easier to explain verbally than on paper. The following tables display a new list of Strengths and Weaknesses, and attached is the list of the old ones.

Strengths		Weaknesses
Strong Voice	Entertaining	Slow Down Pace
Good Direction	Dresses Professional	
Knowledgeable	Teaches neat Stuff	
Good notes	Clear Voice	
Good Strategy	Good Handout	
Clear	Good Understanding of Material	
Concise		
Good Examples		

With the passage of time and PBL sessions, the team has become much more cohesive, and the understanding amongst the members has increased a huge amount. The Perry shift as stated has moved to a 4.5/5 on a personal level. The level of learning from the group members has increased too. As stated in the previous PBL, our group is now a team, and we are a great team, and every session sees us getting better and better. I would also like to thank you for giving me an extension, I have definitely had bad spells of stress at school, but never as bad as the one I had a till yesterday.

Post Teach Meeting Reflections

Teach notes: submitted and received

Quality: Great job amongst members

Examples: plentiful

Teachers:

Mark: good notes, good explanations, sounded really tired, can't blame him, been really busy

Mohammed: cheerful as usual, great notes, explained well, but needs to be a little more detailed

Jeff: Too quiet, could be a little more of an extrovert, will definitely increase his ability to explain

Kevin: This gentleman is the king of explaining things. He does his job well, and always makes it a point to laugh at the end of it to ease the mood.

Myself: I think I am the best explainer in the team, my ways of teaching are very different and I like to use examples that give an idea of a very real time and real thought processes. I have used this way of teaching for many years, as a tutor to younger kids, and still do.

Topics taught:

Somewhat overwhelming amount of information in one day. But reading helped, managed to make good sense of it in the later stages.

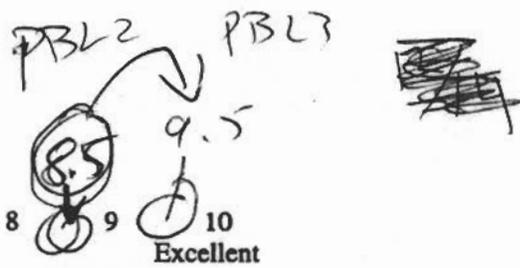
Comment:

I think learning about the economic details of engineering has given us an upper hand in the real world that many other students might not have!

Table 36-2. Some evidence-based targets for Lifelong learning skills, Form 3600 © copyright, Donald R. Woods, 1999

Lifetime learning we define as learning how to learn so that whatever comes our way we empower ourselves to master the new knowledge.					
Evidence-based targets	Progress toward internalizing these targets				
	20%	40%	60%	80%	100%
● Consider peers and classmates as resources to help me see my learning needs, to help me plan my learning and to provide new ideas so that I can learn from them.					✓
● Able to assess learning needs realistically.					✓
● Able to create observable, unambiguous and achievable learning objectives to match or satisfy my needs. Use these to assess progress.					✓
● Can relate to teachers and instructors as resources, facilitators and helpers rather than as the sole source of knowledge. Have acquired an attitude toward learning comparable to Perry level 5.					✓
● Able to identify people and material resources needed to achieve my learning objectives.					✓
● Able to shift from being a dependent learner through being an independent learner to being an interdependent learner.					✓
● Able to devise a time plan and stick to it reasonably well.				✓	
● Willing to assume responsibility and ownership for the tasks in learning: (goal setting, resource identification, learning, assessment).					✓
● Meets contract commitments to teach others.					✓
● When teaching others, uses the principles of learning and addresses differences in learning styles (instead of "reporting information" and expecting the learner to sort it out).					✓
● When learning a "difficult" topic, willing to accept the challenge to unravel the complexity (instead of skipping over it and "hoping it won't be on the exam").					✓

A-2#
MPS 36-2



0 1 2 3 4 5 6 7 8 9 10
Poor Fair Good Very good Excellent

Comments:

2 areas work not accomplished, giving a
12/14 rat.

MPS 36 Self-directed learning or lifelong learning in the context of small group, self-directed, self assessed PBL

- 1.1 Given a term listed under "concepts introduced", you should be able to give a word definition, list pertinent characteristics and cite an example.
- 2.1 Given a problem, you will ask questions, explore issues so that within 30 min, as a group of five, you will be able to identify all of the five to six major issues, and these shall agree within 95% of those identified by the tutor.
- 2.2 Given a problem, you will be able to list the possible knowledge you would need to know to solve the problem; your list should agree within 80% of the list of others in your group and within 85% with the list of the facilitator/tutor. c122
- 3.1 Given a problem and a list of the possible knowledge and resource available, you will create learning objectives and methods of assessment. These will be 90% acceptable according to the criteria for self-performance assessment (in MPS 3)
- 3.2 Given the learning objectives and methods of assessment, you will be able to identify reasonable and pertinent sources of information and be able to allocate the resources to achieve the objectives in the time available.
- 3.3 Given the learning objectives, you will create for yourself examination questions that are consistent with the objectives. These will be judged by peers and or tutor to be 90% acceptable.
- 3.4 Given that other members of the group have acquired key knowledge pertinent to the situation, you will ask questions so that you can learn from them the knowledge you need. You will interact such that they will rate a willingness above 70% to continue to share information with you.
- 3.5 Given that you and your group have completed a teach meeting, you will pause and write reflections once every ten minutes about the process used.
- 5.1 Given that you have contracted to teach topics to meet selected learning objectives of the group, you will learn the knowledge, and with due consideration of the learning styles of other members in your group, prepare "teach notes" and use these to teach the other group members such that you receive feedback from all members of the group with ratings > 6/7 for knowledge and > 6/7 on quality of instruction.
- 5.2 Given the first PBL teach session described in Section 5.1 and given the feedback of your five strengths and two areas to work on, within three PBL cycles you will maintain all your strengths and shift one of your weaknesses to be a strength. The evidence will be the feedback from all the members of your PBL group.
- 5.3 Given the initial problem and the solution to the problem (from 3.6), you and the group will elaborate in writing to identify at least thirteen different perspectives. The elaboration will be assessed as being correct and enriching by the tutor or a group of peers.
- 6.1 Given the initial problem and the knowledge that you and the group have learned and your solution to the problem, you and the group will use the knowledge to solve the problem. You and the group will self assess that the problem solving process, the answer to the problem and lifelong learning was the best you could do with the time available.
- 6.2 Given the feedback from a Perry inventory, you will be able to judge the degree to which this assessment is valid; you can list the five strengths and two areas to work on such that in a cycle of six PBL sessions you will shift such that a retest using the Perry inventory will show a rating of > 4 for all dimensions of the inventory.
- 6.3 Given skill in self assessment (MPS 3) you will create a learning journal in which you record and self assess your progress as



A-25 results for PBL1

Quality of Knowledge: 8/8
Quality of Instructions: 7.8/8
Followup: 7.8/8

Strengths		Weaknesses
Well prepared	Useful/Good Handout	Speed
Confident	Clear Voice	Spell Check
Simple	Concise	Define Terms in Handout
Good Research	Understand Material	
Knowledgeable	Willingness to -	
Good Overview	answer questions	
Sexy!		

Excellent
results for PBL1?

Based on the almost perfect marks in the teach meeting Quality and Followup, the teach meeting was a success on my part. Of the strengths and weaknesses, similar ones were stated as of the first teach meeting. Of the weaknesses, I have worked on the reducing the speed of speech, and believe that I need to work more on slowing down, and addressing the technical definitions more clearly. My teach notes were not very elaborate because I believe that verbal explanation of the concepts is more effective than a written one, especially when I had to outline the Risk Factors of each of the teachings of the other members.

To follow up what I missed in the first PBL report, I have done the analysis of MPS 36 for this meeting, relating the learning objectives to our style of teaching, learning, and understanding. I believe a score of 13/14 is acceptable, where 3.4 and 3.5 are to be worked on. The teach meeting was a success, but there are areas still to be more familiar with, and the writing of reflections was done, but not to an extent that is totally acceptable.

To conclude the report, I would like to point out that, in a real world situation, a group – or in our case, a team – like MIMAC is the successful point in any kind of operation and task assigned to it. We have zero problems, amongst each other, and with the tasks given to us. We solve the problems and tasks, with great efficiency and to the satisfaction of each other, and our own work. The appreciation amongst the members is fantastic and the morale is soaring. We clearly are one of the first groups to finish and pack up, and talk about the weekends and the other factors leading up to it.

This is a marked improvement

I would like to apologize for my terrible performance in the first PBL report, and sincerely hope that this report is a better reflection of my skills and abilities. I am very thankful to have a chance to take a course, where I learn something new with every passing minute.

Sincerely,
Fahim Ahmed.

This is a memo; not a letter.
Initial or Sign at the top

Fahim,
You have A+ smarts. I find it discouraging when your reports don't give me a chance to reward those smarts with marks.
Drew

Guys!
How's it going?

Lets make this really easy!

I am going to buy a new pump for my new cottage.

I go to the pump people and tell them what I need, they give me a quote for a 'carbon steel' pump, and I purchase it for \$950, no taxes.

After purchasing it, they tell me that it will cost me \$50 to get it shipped to the cottage.

That is my FOB cost: \$1000. A CE value will be given to us, say 100.

If the L+M* factor is given, for example 2.5.

We can effectively calculate L+M cost.

How? $L+M^* \text{ cost} = L+M^* \text{ factor} \times \text{FOB} = 2.5 \times 1000 = \2500

But that's not it, we need the pipes the base, the drills, etc. etc. to get this pump to start working!

These now are out L+M cost of instrumentation! This can either be a factor of the total L+M or just an estimate can be given. Ex. \$200 along with some CE value, say 50.

Now we need to find the cost for instrumentation for the pump at a CE value of 100 to match our 'carbon steel' pump! So get a ratio: $\$200 \times 50 / 100 = \100

Surprised it went down? So was I when I was doing this! But it goes down because the *scale* of the equipment matters, I have a good feeling that CE values decrease with increasing scales!

Anyways, the L+M costs now increase to $\$2500 + \$100 = \$2600$

NOW! My 'carbon steel' pump is not going to do, because of incessant corrosion due to acidic ground water! So I need another type of pump, another 'alloy' pump. Say 'Aluminum-xxx' pump.

Starting to make sense?

Right, the pump people tell me, the FOB costs for the new alloy pump is 1.5 times the 'carbon steel' pump. Simple, find the new L+M cost!

1.5 times the FOB for 'carbon steel' pump = $\$950 \times 1.5 = \1425 .

Now we use a graph like figure 15-3 in the handout to find the ratio for the alloy vs. the carbon steel. Say for example the ratio is 0.8.

The L+M* factor is now = L+M* factor for 'carbon steel' pump * the ratio = $2.5 \times 0.8 = 2$.

Therefore the new L+M* cost = FOB cost for 'Aluminum-xxx' pump $\times 2 = \$1425 \times 2 = \2850 .

Add the same L+M cost for instrumentation = \$100 = \$2950 at a CE value of 100.

All these costs will be with a +/- percentage value depending on the product. The correlations can be found in the rules of thumb book!

Any questions, please call me 905 523 1771, or email me at fahym84@hotmail.com!

Cheeeeeeeers!!

Fahim!

MIMAC Inc has gone universe wide!

We have decided to use the plutonium reserves on meteor Jambalaya to produce organic energy canisters, called protoculture, for Battle Cruiser McTimbits. This requires the fusing of the new alien variety of nitrogen based energy cells, with plutonium injected nuclei. This will give us enough power to produce energy in McTimbits for 100 light years per annum.

Your company _____ has been given the task of BL estimation for the energy plant, which will produce 100 Mg/annum of protoculture.

2 units of plutonium + 1 energy cell = 1 unit of protoculture.

Hint: (That's 200Mg/annum of plutonium + 100Mg/annum of energy cells!!)

The data for the BL estimation for the two plants are as follows:

The space is our territory, so we do not pay taxes. **The predicted inflation rate in space is 2%.**

Plutonium:

It costs **\$200 for 50Mg/annum plutonium, n=1** for the range of 10-500Mg/annum (so you are in range) at **CE 100**.

Energy Cells:

It costs **\$400 for 50Mg/annum energy cells, n=1** for the range of 10-500Mg/annum (so you are in range) at **CE 100**.

Find the two costs, and add them to give us a final quote for the cost for one year from now, at a **current CE of 100**.

Formula:

$$\text{COS } t_{\text{now}} = \text{COS } t_{\text{reference}} \left(\frac{\text{size}}{\text{size}_{\text{reference}}} \right)^n \quad \text{Hint: page 13 of handout!}$$

Thank you for your expertise.

Regards,

Group MIMAC

To go where not Chem-Eng-er has gone before!

(corny music)

A-28

ANSWERS:

Plutonium: cost = $\$200(200/50)^1 = \800

Correct to current time: = $\$800 \times 100/100 = \800

Adjusting to one year of inflation at 2% = $\$800 \times 1.02 = \816 One year from now!

Energy Cells: $\$400(100/50)^1 = \800

Correct to current time: = $\$800 \times 100/100 = \800

Adjusting to one year of inflation at 2% = $\$800 \times 1.02 = \816 . One year from now!

Total = $\$816 + \$816 = \$1632$. One year from now!

Fig 36-1: Feedback to Fahid Ahmed for Unit 3
 on the Learning components Date Nov 1, 05
 Present & on time: Present but late by _____ min.
 All members of our group present except for _____

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these	A few but major omissions		Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
<input type="radio"/> 6	<input type="radio"/> 7	<input type="radio"/> 8	<input checked="" type="radio"/>	

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Followup: from this presentation I will have to:

_____ _____ _____ _____ _____ _____

study the subject on my own; I learned nothing from the presentation

practice on some problems; however, I have all the fundamentals I need to know.

Strengths
entertaining
seems professional
teaches neat stuff
clear voice.

Areas to Improve on

Fig 36-1: Feedback to Fahim for Unit 3
on the Learning components Date Nov. 1
Present & on time: Present but late by _____ min.
All members of our group present except for _____

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Followup: from this presentation I will have to:

<input type="radio"/>	<input checked="" type="radio"/>						
-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	----------------------------------

study the subject on my own; I learned nothing from the presentation

practice on some problems; however, I have all the fundamentals I need to know.

Strengths good content
clear voice
good understanding of material

Areas to Improve on

Fig 36-1: Feedback to Fahim for Unit Teach 3.
on the Learning components Date Nov. 1/05
Present & on time: Present but late by _____ min.
All members of our group present except for _____

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input checked="" type="radio"/> 7	<input type="radio"/> 8

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Followup: from this presentation I will have to:

<input type="radio"/>	<input checked="" type="radio"/>						
-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	----------------------------------

study the subject on my own; I learned nothing from the presentation

practice on some problems; however, I have all the fundamentals I need to know.

Strengths

strong voice
good direction
knowledgeable
good notes

Areas to Improve on

slow down pace

Fig 36-1: Feedback to Fahim for Unit 3
on the Learning components Date 1st Nov.
Present & on time: Present but late by _____ min.
All members of our group present except for _____

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Followup: from this presentation I will have to:

<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8
study the subject on my own; I learned nothing from the presentation							practice on some problems; however, I have all the fundamentals I need to know.

Strengths

- good strategy
- clear
- concise
- good examples

Areas to Improve on

Fig 36-1: Feedback to FATHIM AHMED for Unit 3
on the Learning components Date NOV. 1
Present & on time: Present but late by _____ min.
All members of our group present except for _____

Quality of Knowledge: good intellectual understanding of the topic, the material supplied was complete and appropriate.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Quality of Instruction: he/she was here on time, the presentation was focused on the new knowledge; good choice of material and medium with effective communication and resource material supplied.

None of these	A few but major omissions	Most of these	All of these
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
<input type="radio"/> 5	<input type="radio"/> 6	<input type="radio"/> 7	<input checked="" type="radio"/> 8

Followup: from this presentation I will have to:

study the subject on my own; I learned nothing from the presentation

practice on some problems; however, I have all the fundamentals I need to know.

Strengths
clear voice.
good handout
good understanding

Areas to Improve on
pace.

To: Dr. D.R. Woods and Santiago Faucher
From: Kathryn Grundy
Date: November 10, 2005
Topic: Chairperson feedback report #2

Dr. Woods and Santiago:

Having facilitated the PBL Assess meeting for Case 6 on November 3, 2005, I am submitting my chairperson feedback report.

The assessment meeting went very well. We were able to successfully choose a problem to give to another group, as well as solve the problem given to us. We received a mark of 10/10 for our chosen problem and a score of 8.5/10 for the problem we solved. The Personal Satisfaction with decisions made overall group score was 34 out of a possible 40 marks. This is slightly lower than the last meeting I facilitated (36/40), but could be attributed to the fact that the assessment meetings are challenging for us.

Pertaining to objectives 1.1, 6.1, and 6.2 of MPS 29 of the courseware, the group score for Task of the meeting was 25 out of a possible 28 marks. The group score for Morale of the meeting was 26 out of a possible 28 marks. This indicates that the group is generally content with our ability to perform the task and our morale. In the previous meeting I chaired, the Task and Morale scores were slightly higher (26/28 for Task, and 27/28 for Morale).

Also concerning objectives 1.1, 6.1, and 6.2, my score for chair's role in Task was 208 out of a possible 240 marks. In the previous meeting I chaired, my score was 198 out of 240. I have made a significant improvement in facilitating the task, despite the overall group rating of Task being slightly lower. My contribution as chairperson towards group task success is increasing. My score for chair's role in Morale was 208 out of a possible 240 marks. In the previous meeting I facilitated, my score was 181 out of a possible 240. Similar to my Task score, the increase in my Morale score is despite a slight decrease in overall group Morale rating. This indicates that I am a morale booster in the meetings I facilitate. An indication that I am successful in keeping morale high are the humorous comments under areas for improvement that I should "feed the group", "bring snacks", etc. Since one member indicated that I should give more praise to group members, I will remember this to even further contribute to the morale of the group. Objectives 1.1, 6.1, 6.2 have been completed 95%. This is a significant accomplishment since in my pretest I rated myself on a scale of 1 to 10 as aware of chairperson skills 4 and my skills in facilitating 2.

I have completed objective 6.3 100% by shifting one weakness to a strength. During the first meeting I facilitated, two members wrote that I should remember to include the names of all group members on the agenda list. For my second meeting I ensured my agenda was complete. Although this seems like a minor mistake, in other groups an important team member may not attend the meeting. Omitting names on the agenda could potentially be very insulting to some people and affect morale of the group.

Concerning objective 6.4-6.6, I prepared and distributed an agenda prior to the meeting and completed 100% of the items listed in the agenda. As discussed above, I have received higher than average ratings on both task and morale for the conduct of the meeting. I have completed objectives 6.4-6.6 100%. An area that I still need to improve is my skills at elaborating and explaining issues of the meeting. I hope to have the chance to do so in future meetings.

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Table 1: List of strengths and areas to improve.

Strengths		Areas to work on	
1 st meeting	2 nd meeting	1 st meeting	2 nd meeting
- well organized	- organized	- include all group members on agenda list	- explain more/elaborate more
- well spoken	- helpful	- explain and elaborate more on what you have said	- bring some snacks
- good facilitator	- good agenda	- try to include all group members on agenda	- food
- very good agenda	- organized		- look at time
- took control	- good communication		- more praise
- organized	- excellent agenda		- feed the group
- followed agenda	- organized		
- got back group on track whenever needed	- involved everyone		
- asked for peoples input	- excellent communication & direction		
- kept morale high			
- very organized and thorough agenda			
- kept us on track			

Table 2: Summary of numerical values from feedback reports.

Rating Type	1 st Meeting	2 nd Meeting
Overall Task	26/28	25/28
Overall Morale	27/28	26/28
Chair's role in Task	198/240	208/240
Chair's role in Morale	181/240	209/240
Satisfaction with decisions made	36/40	34/40

Agenda for Assess Meeting for Case 6

Date Issued: November 2, 2005

Date & Time of Meeting: Thursday November 3, 2005 (11:30 am)

Location: JHE 326H

Attendees/Distribution: Graham Lambert, Derrick Popovich, Dina Ahmed, Kathryn Grundy, Marlene Stahel

Purpose: Assessment of Case 6 Learning Objectives

Prewrite: Prepare assessment question with solutions.

Bring:

- ChE 4N4 courseware
- Assessment question with solutions
- Dina: alloy information
- Completed chairperson feedback form for Marlene
- Completed teach feedback forms
- Blank chairperson form.

Topics/Items:

- Go over agenda for the meeting (1 min).
- Appoint a note-taker for the meeting (not necessarily the minute taker) (1 min).
- Read each person's question aloud (5 min).
- Choose a question to give to another group (3 min).
- Receive an assessment question from another group and solve it (30 min).
- Score the chosen assessment question (to be done by whoever created the question) and have our solved question scored (5 min).
- Fill out and distribute chairperson/teach feedback forms (5 min).

OR = 6 + 6 + 1 + 6 = 26 (possible)
 morale = 6 + 7 + 6 + 7 = 26 (possible)
 role task = 46 + 54 + 60 + 48 = 208 (240)
 morale = 47 + 54 + 60 + 48 = 209 (240)

7 + 8 + 10 + 9 = 34

Kathy

Table 29-1: Date of meeting: _____ Group: 5 Chairperson: _____

Agenda circulated ahead of time, yes no G; start on time, yes G, no G; end on time, yes G, no G
 ! Task: Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. The accuracy in the group's answer matched the time available. Group avoided contributing excessive information.

	None G 1	Few but major omissions G 2	Most features demonstrated G 3	All of these behaviours G 4	G 5	G 6	G 7
Total	46						
15 to 20	Excellent & ahead of time	17	Used very well			Mega positive: clarified, brought back on task, monitored Task	15
10 to 14	Poor & ahead of time		OK	14		Some positive as needed: clarified, back on task, monitored Task	
5 to 9	Excellent but handed out at start		Fair			Neutral because working well	
0 to 4	Poor and handed out at start						
0 to -4	Excellent created at start		Poorly			Neutral when help was needed	
-5 to -9	Poor created at start						
-10 to -15	No agenda		Not used			Kept dominating as leader, when facilitator need, Solved problem for group, when they didn't want that solution	
-16 to -20						Mega negative, imposed own ideas and answers. Dictator	

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

	None G 1	Few but major omissions G 2	Most features demonstrated G 3	All of these behaviours G 4	G 5	G 6	G 7
Total	47						
15 to 20	Excellent & ahead of time	17	Used very well. Comfort high because know goals	15		Skilled observer of interpersonal process, praiser, facilitates, conflict resolution and provides tension relief as needed.	15
10 to 14	circulated ahead but missing prework & bring		Comfort moderate, can infer what to do ahead of time			Some skill and intervention	
0 to 9			Fair			No intervention because all working well	
-1 to -9	Some frustration; feel ill-prepared because didn't know what to prework or bring		Poor			No intervention when help was needed	
-10 to -15	No agenda, High distress		Not used, high distress because unclear as to where going			Some, causes lower-than-norm morale because of criticism, defensiveness, contemptuousness, stubborn, conflict	
-16 to -20						Mega causes tension, seeks personal goals, critical, abusive, self centered and defensive, contemptuous, ignores others	

Personal Satisfaction with decisions made: G 0 extremely dissatisfied... 5 OK... 7 10 very satisfied

! Strengths
 • organized
 • helpful

Areas to work on
 • explain more / elaborate more

Table 29-1: Date of meeting: Nov 3 Group: 5 Chairperson: Kathryn

Agenda circulated ahead of time, yes G no G; start on time, yes G, no G; end on time, yes G, no G

! Task: Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. The accuracy in the group's answer matched the time available. Group avoided contributing excessive information.

	None G 1	Few but major omissions G 2	G 3	Most features demonstrated G 4	G 5	All of these behaviours G 6	G 7
Total	54						
Agenda: Names, time, place, purpose, prework, bring, topics, timing	Agenda: Names, time, place, purpose, prework, bring, topics, timing		Use of agenda: Keep on topic, effectively & not disruptively keep on time, 20 min rule		Facilitation as needed when team functioning below norms on Task		
15 to 20	Excellent & ahead of time 18		Used very well 18		Mega positive: clarified, brought back on task, monitored Task 18		
10 to 14	Poor & ahead of time		OK		Some positive as needed: clarified, back on task, monitored Task		
5 to 9	Excellent but handed out at start		Fair		Neutral because working well		
0 to 4	Poor and handed out at start						
0 to -4	Excellent created at start		Poorly		Neutral when help was needed		
-5 to -9	Poor created at start						
-10 to -15	No agenda		Not used		Kept dominating as leader, when facilitator need, Solved problem for group, when they didn't want that solution		
-16 to -20					Mega negative, imposed own ideas and answers. Dictator		

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

	None G 1	Few but major omissions G 2	G 3	Most features demonstrated G 4	G 5	All of these behaviours G 6	G 7
Total	54						
Agenda:	Agenda:		Use of agenda:		Facilitation as needed when team functioning below norms on Morale		
15 to 20	Excellent & ahead of time 18		Used very well. Comfort high because know goals 18		Skilled observer of interpersonal process, praiser, facilitates, conflict resolution and provides tension relief as needed. 18		
10 to 14	circulated ahead but missing prework & bring		Comfort moderate, can infer what to do ahead of time		Some skill and intervention		
0 to 9			Fair		No intervention because all working well		
-1 to -9	Some frustration; feel ill-prepared because didn't know what to prework or bring		Poor		No intervention when help was needed		
-10 to -15	No agenda, High distress		Not used, high distress because unclear as to where going		Some, causes lower-than-norm morale because of criticism, defensiveness, contemptuousness, stubborn, conflict		
-16 to -20					Mega causes tension, seeks personal goals, critical, abusive, self centered and defensive, contemptuous, ignores others		

Personal Satisfaction with decisions made: 8 0 extremely dissatisfied...5 OK..... 10 very satisfied

! Strengths

- good agenda
- organized
- good communication

Areas to work on

- bring some snacks.

Table 29-1: Date of meeting: Nov 3 05 Group: 5 Chairperson: Kathryn

Agenda circulated ahead of time, G, no G; start on time, G, no G; end on time, G, no G

! Task: Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. The accuracy in the group's answer matched the time available. Group avoided contributing excessive information.

	None 1	Few but major omissions 2	3	Most features demonstrated 4	5	All of these behaviours 6	7
Total <u>60</u>	Agenda: Names, time, place, purpose, prework, bring, topics, timing		Use of agenda: Keep on topic, effectively & not disruptively keep on time, 20 min rule			Facilitation as needed when team functioning below norms on Task	
15 to 20	Excellent & ahead of time		Used very well			Mega positive: clarified, brought back on task, monitored Task	
10 to 14	Poor & ahead of time		OK			Some positive as needed: clarified, back on task, monitored Task	
5 to 9	Excellent but handed out at start		Fair			Neutral because working well	
0 to 4	Poor and handed out at start						
0 to -4	Excellent created at start		Poorly			Neutral when help was needed or unskilled and unable to help	
-5 to -9	Poor created at start						
-10 to -15	No agenda		Not used			Kept dominating as leader, when facilitator need, Solved problem for group, when they didn't want that solution	
-16 to -20						Mega negative, imposed own ideas and answers. Dictator	

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

	None 1	Few but major omissions 2	3	Most features demonstrated 4	5	All of these behaviours 6	7
Total <u>60</u>	Agenda:		Use of agenda:			Facilitation as needed when team functioning below norms on Morale	
15 to 20	Excellent & ahead of time		Used very well. Comfort high because know goals			Skilled observer of interpersonal process, praiser, facilitates, conflict resolution and provides tension relief as needed.	
10 to 14	circulated ahead but missing prework & bring		Comfort moderate, can infer what to do ahead of time			Some skill and intervention	
0 to 9			Fair			No intervention because all working well	
-1 to -9	Some frustration; feel ill-prepared because didn't know what to prework or bring		Poor			No intervention when help was needed or unskilled in facilitation	
-10 to -15	No agenda, High distress		Not used, high distress because unclear as to where going			Some, causes lower-than-norm morale because of criticism, defensiveness, contemptuousness, stubborn, conflict	
-16 to -20						Mega causes tension, seeks personal goals, critical, abusive, self centered and defensive, contemptuous, ignores others	

Personal Satisfaction with decisions made: 0 extremely dissatisfied... 5 OK... 10 very satisfied

! Strengths

- excellent agenda
- organized

Areas to work on

- Foot
- look at time (lol)

A-40

Table 29-1: Date of meeting: Nov 3/05 Group: 5 Chairperson: Kathryn

Agenda circulated ahead of time, yes G no G; start on time, yes G, no G; end on time, yes G, no G
 Task: Problem defined, many issues and hypotheses explored, criteria listed and the issues prioritized. Refrained from early closure. Task carried out and looked back at the result to assess it. Group agreement as to goals. Process was active with monitoring. Completed task on time. The accuracy in the group's answer matched the time available. Group avoided contributing excessive information.

	None G 1	Few but major omissions G 2	3	Most features demonstrated G 4	5	All of these behaviours G 6	7
Total						(6)	
(48)		Agenda: Names, time, place, purpose, prework, bring, topics, timing		Use of agenda: Keep on topic, effectively & not disruptively keep on time, 20 min rule			Facilitation as needed when team functioning below norms on Task
15 to 20		Excellent & ahead of time (18)		Used very well (16)			Mega positive: clarified, brought back on task, monitored Task
10 to 14		Poor & ahead of time		OK			Some positive as needed: clarified, back on task, monitored Task (14)
5 to 9		Excellent but handed out at start		Fair			Neutral because working well
0 to 4		Poor and handed out at start					
0 to -4		Excellent created at start		Poorly			Neutral when help was needed
-5 to -9		Poor created at start					
-10 to -15		No agenda		Not used			Kept dominating as leader, when facilitator need, Solved problem for group, when they didn't want that solution
-16 to -20							Mega negative, imposed own ideas and answers. Dictator

Morale: Group relaxed; enjoyed working together. They gave emotional support to each other and were able to express disagreement or disappointment directly. Seven fundamental rights preserved. Members are enthusiastic and involved.

	None G 1	Few but major omissions G 2	3	Most features demonstrated G 4	5	All of these behaviours G 6	7
Total						(7)	
(48)		Agenda:		Use of agenda:			Facilitation as needed when team functioning below norms on Morale
15 to 20		Excellent & ahead of time (16)		Used very well. Comfort high because know goals (16)			Skilled observer of interpersonal process, praiser, facilitates, conflict resolution and provides tension relief as needed. (16)
10 to 14		circulated ahead but missing prework & bring		Comfort moderate, can infer what to do ahead of time			Some skill and intervention
0 to 9				Fair			No intervention because all working well
-1 to -9		Some frustration; feel ill-prepared because didn't know what to prework or bring		Poor			No intervention when help was needed
-10 to -15		No agenda, High distress		Not used, high distress because unclear as to where going			Some, causes lower-than-norm morale because of criticism, defensiveness, contemptuousness, stubborn, conflict
-16 to -20							Mega causes tension, seeks personal goals, critical, abusive, self centered and defensive, contemptuous, ignores others

Personal Satisfaction with decisions made: 9 0 extremely dissatisfied...5 OK.... 10 very satisfied

! Strengths

Areas to work on

- involved everyone
- excellent communication & direction

- more praise
- feed the group

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