Teaching *Petroleum Geology* in third year using problem based learning

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Abstract

Problem based learning (PBL) is a form of learning by doing and has been used in the University context since the late 1970s. This technique has been used with third year students in the School of Ocean and Earth Science, Tongji University. The students are exposed to situations commonly encountered in professional practice that reflect scope and complexity of petroleum geology problems. Students work in groups and formulate hypotheses, devise solutions, and develop progressively more sophisticated solutions for the petroleum geology problems presented to them. Problem based learning is used in subsequent petroleum geology teaching in the final year where students undertake an extended project under the supervision of an academic project leader. This reinforcement, combined with a focus on increasingly complex problems focused on petroleum generation, migration, reservoir accumulation, and other such practical situations, enables students to employ critical thinking skills and develop the confidence necessary for professional practice. The introduction of problem based learning into the petroleum geology curriculum has given students the opportunity to develop the problem solving skills necessary to manage complex petroleum geology.

Introduction

The field of petroleum geology is concerned with the geological processes that form petroleum and natural gas (generation, migration, preservation and accumulation) and the methods of exploration and exploitation of this resource. Petroleum geology was established as a stand-alone course for third year students in the School of Ocean and Earth Science, Tongji University in 1974. Normally 25-30 students take the course in the third year. These students are taught the relevant concepts, principles and other theories. Interested students will go on to take a more thorough training in their fourth year in which they are generally given a real, everyday exploration or petroleum recovery project to work on, discuss and solve. These students will often find employment in a mineral company when they graduate. Currently we mostly use the so-called 'traditional teaching techniques' in our third year course, which consists almost entirely of teacher-centred lectures. Students report that they find this style of instruction boring; that there is too much content; too many concepts and principles to rote learn; and too much work to complete. This dissatisfaction is a likely explanation for the decrease in student numbers that we experienced several years ago – which was why we introduced PBL into our fourth year program.

So, how is the PBL approach different to our traditional approach? Our aim in using PBL is: to engage students' curiosity; to motivate students to identify and research the required concepts and theories by themselves; for students to work in groups and share ideas with each other; and to improve the students' ability to integrate information and communicate with us and each other. By introducing inquiry-based questions into lectures, and small PBLs into practical classes, the students are prepared for active engagement petroleum geology projects; and their curiosity is stimulated and rewarded if they decide to continue with petroleum geology in fourth year.

Why do we want to use PBL?

'Problem based learning provides an alternative to traditional educational methods by having learners function as active participants in learning, rather than passive recipients of information. An interactive approach to critical thinking and practical judgment is used. Critical thinking based on students' current knowledge provides the springboard for the development of new concepts and reasoning' (Bechtel, Davidhizar and Bradshaw 1999). In PBL, realistic situations provide students with

the opportunity to engage in self-directed, interdependent learning and to develop solutions to actual problems.

PBL is both a curriculum and a process. The curriculum consists of carefully selected and designed problems that demand from the learner acquisition of critical knowledge, problem solving proficiency, self-directed learning strategies and team participation skills. The process replicates the commonly used systemic approaches to resolving problems or meeting challenges that are encountered in students' life and career.

At first, PBL is designed about eight tasks, as defined below.

1. Explore the problem, create the hypothesis, identify issues and elaborate.
2. Try to solve the problem with what you currently know. A clearer idea of what you already know that is pertinent will emerge from this.
3. Identify what you do not know and therefore what you need to know because your lack of knowledge is impeding the solution of the problem.
4. Prioritise the learning needs, set learning goals and objectives, and allocate resources so that you know what is expected of you by when. For a group, members can identify which tasks each will do.
5. Undertake self-study and preparation.
6. For a group, share the new knowledge effectively so that the entire group learns the information.
7. Apply the knowledge to solve the problem.
8. Give yourself feedback by assessing the new knowledge, the problem solution and the effectiveness of the process used. Reflect on the process.

The purpose of using PBL in petroleum geology education is to produce exploration professionals who are capable of managing actual problems. We wish to give students a more skill-based training, requiring a more student-centred focus and learning environment. Students are more likely to be responsible for their own learning. Competition for jobs is very strong and PBL provides a work-like experience. This is the goal of our petroleum geology education: to move students down a path from novices to competent, self-directed, critically thinking practitioners. It is through active participation that students apply the knowledge gained to explore a variety of options and design plans that are readily applied to actual explorer situations.

How can we apply PBL in this course?

How do we introduce PBL into the classroom? It is by changing our approach in the classroom. At the beginning of the course, we will give students some questions to motivate them to engage with the subject and PBL. For example:

- What kind of fuel energy do you rely on every day?
- Why do wars occur in the Middle East so often?
- Where should we explore for oil in the future? and
- Do you want to work in oil exploration?

These questions can encourage students to pay better attention in lectures. The knowledge is relevant to the students' future professional role. They will want to find out more about the subject because there are good job opportunities in this field. The teacher should explore problems, create and test hypotheses, identify issues and explain clearly.

How can we change over from a traditional teaching approach to a PBL approach in our third year courses? By posing questions and working through mini-problems instead of a providing a constant stream of content in lectures. For example, the following question should be given to the students. A potential oil trap has been found by a geologist (Figure 1). Is there any petroleum in this trap? An exploration well was drilled that proved there is oil in the trap. But how much oil does the trap hold? Is this trap commercially viable? This can be followed up by expanding the problem and providing more information. Firstly, provide more data: another four wells were drilled that only yielded water. So the further questions are: is it worth continuing to explore this field? How much investment is required for exploitation? What is the oil field's shape and volume? How much productive area is present in the oil field? How many wells should be drilled? Which wells should be used for injection? The students should have the opportunity to think about these questions and then attempt to answer or solve them. In this way the knowledge they acquire can be learned actively and in a more entertaining way.

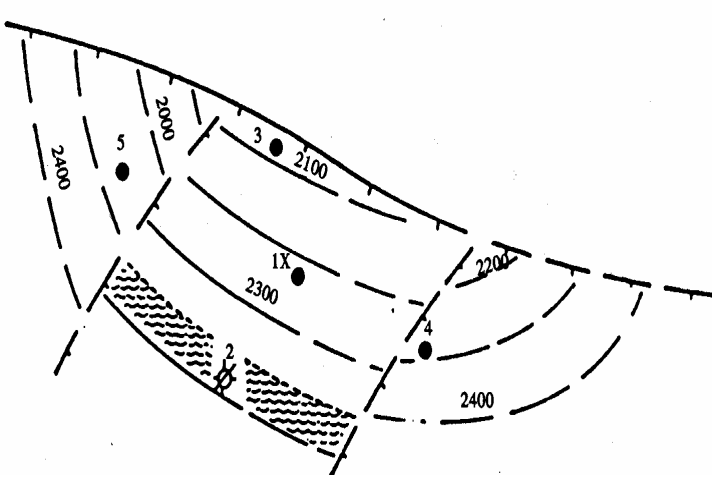

Figure 1. Design wells: problem based learning stimulus material

What skills do students obtain for themselves by working through solving problems? We think that they include four aspects at least. These are knowledge skills, thinking and interpretation skills, personal skills and practical skills.

Knowledge skills – student should have a body of knowledge in the field; they should be able to identify, access, organise and communicate knowledge; they should be able to apply theory to practice in familiar and unfamiliar situations; and they should have an understanding of the requirements and characteristics of successful oil exploration.

Based on the knowledge skills training, we will give students questions about oil generation characteristics:

- What kind of material can generate oil?
- Where can these materials be found?
- What kind of facies are present in the oil-field and what are the relationships between them?
- How do these materials generate oil?
- How much oil did the different materials generate?

Thinking and interpretation skills – students should be able to exercise critical judgment; be capable of rigorous and independent thinking; be able to account for their decisions; and employ their imagination and produce innovative solutions. Petroleum forms at depth in the ground. It can migrate from one place to another. But we can't observe these events directly. So imagination skills should be trained. Students will be able to recognize when it is appropriate to use their newly acquired knowledge. To help them do this we will give students questions such as:

- Why does oil migrate from one place to another?
- When did the oil migrate?
- Which direction did the oil migrate in?
- How long did it take for the oil to migrate from its source to the reservoir?

Personal skills – students should have the capacity and desire to be life-long learners; the ability to plan and achieve goals in both the personal and the professional sphere; the ability to work in a group and the confidence face to problems.

New knowledge is created every day, so the students must have life-long learning skills, so they can acquire and use new knowledge to solve problems. On the other hand, petroleum exploration is a highly risky endeavour because drilling oil wells requires the expenditure of vast amounts of money. For example, drilling an offshore well costs about 100 million dollars. If the well produces petroleum, costs will be met. But if the well is dry or production from it is not commercially viable, the money spent on the well might as well have been thrown away. So making the right decision using modern techniques and up to date knowledge and conceptual models is very important.

Practical skills – students should be able to collate, correlate, display, analyse and report observations; apply experimentally obtained results to new situations; and be confident that they can deal with unexpected findings or results. Knowledge and the ability to use that knowledge are of equal importance.

How can we utilise PBL to improve our teaching?

If we use PBL to teach, will all our problems disappear? Probably not. We think there is a long way to go. Based on the student feedback, some questions are hard to understand; some content isn't relevant; and it is hard to motivate students to be enthusiastic all the time. How can we improve our teaching with PBL? We should introduce new knowledge with a new focus. We will use this technique to provide sound background for decisions and use case studies to reinforce their confidence in making decisions. We will give our third year students workshops and tutorials and opportunities to make site visits to productive oil fields.

Conclusion

Modern teaching theories and educational methods are something like a bunch of keys held in a teacher's hand (Figure 2). They include keys for knowledge, concept, skills door and teaching strategy doors. We can open these doors and help the students experience the improvements that each will bring to our classroom.

What should we change about the way we teach in the future?

We think that teachers should change their role from being the centre of attention and the source of all knowledge, to being a coach and facilitator of the acquisition of that knowledge. The learning becomes student-centred, not teacher-centred. This will lead to the following changes in our third year program:

- less lectures more practical classes;
- more correlative questions;
- more guidance; and
- appropriate changes to the curriculum based on students' feedback.

Changes in fourth year will include:

- less hearing more doing;
- more real petroleum geology analysis;
- more practical examples;
- more images; and
- more topic discussion.

The introduction of problem based learning into the petroleum geology curriculum provides students with an opportunity to develop the skills necessary to manage a complex, real condition. The questions and case studies incorporate aspects of generation, migration and accumulation in a real world situation. This type of exercise can be easily adapted for students using some of our current teaching materials.

Problem based learning can be an effective teaching style if it is sensibly implemented and the problem is well designed, because:

- students obtain and use knowledge and skills for an obvious purpose;
- students are engaged in active learning;

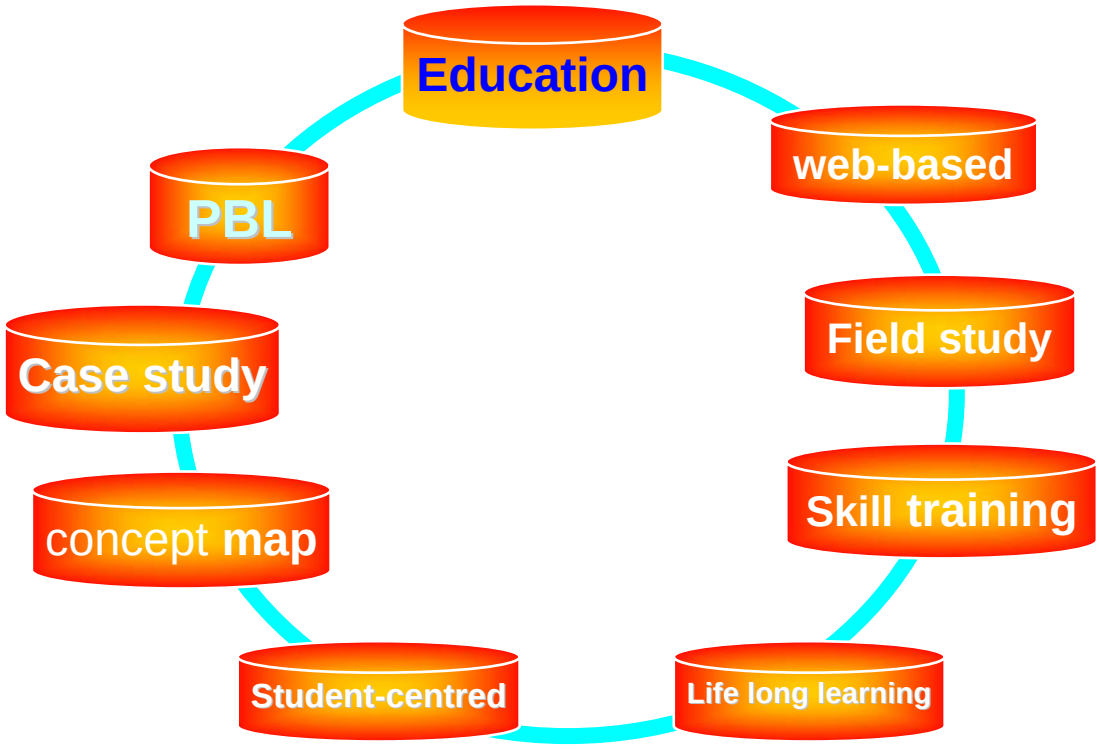

Figure 2. The concept map of education

- students are motivated by the problems before the learning;
- students store the knowledge in memory patterns that facilitate later recall for solving problems;
- outcomes can be achieved by self-direction and self-assessment; and
- online studying and self-assessment can enhance the effectiveness of PBL.

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