The redesign of undergraduate geological course system using contemporary education strategies and approaches

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Abstract

Student-centred teaching and learning strategies and deep-learning are recurring themes in discussions about modern tertiary education. In this paper the problems that geology faces as a discipline and the limitations of traditional geology curriculum are discussed. The possible applications of the contemporary education methodologies in modern geology curricula at Lanzhou University are outlined and an example of modern geology curricula is given.

Introduction

Over the last few decades, tertiary educators have increasingly focused on improving the quality of teaching and learning. A series of pedagogical theories have been developed that focus on student-centred learning. These include collaborative learning practices, and skills-development, problem based learning, etc. A common characteristic of these approaches is the requirement that students take an active role in learning (King 2004). Geology investigates all aspects of the physical earth from its origins and earliest evolution through its four and a half billion years of history, to the dynamics of how it is now changing. Geology is also a field-based science with an emphasis on the concrete facts rather than abstract concepts. Geologists often work in difficult conditions (steep terrain, extreme cold/hot weather, etc). Many of our students accept a place to study at our university because they want a university degree of some type; geology always is usually a 3rd, 4th, ... or even 10th choice. Consequently, geology departments commonly face declining enrolments of geology majors and the possibility of becoming a low-enrolment program that is forced to reinvent itself to foster student interest in earth sciences by moving curriculum and teaching to more contemporary pedagogical approaches. In this paper crucial problems arising from the conventional geology curriculum will be discussed, and several contemporary pedagogical strategies applied to redesigning a possible geology curriculum for implementation at Lanzhou University.

Problems of the traditional geology curriculum system

In Table 1 we have compared the current geology curriculum in use at Lanzhou University, China and The University of Sydney, Australia. At Lanzhou University, the geology curriculum is a conventional one which focuses on discipline-centred teaching styles, with each course focussing on the specific knowledge pertaining to each of the more prominent sub-disciplines of geology. The University of Sydney had a similar geology curriculum until about 10 years ago but is now more focused on problem-solving and gaining content knowledge through application rather than by passive exposure.

The conventional geology curricula previously used at the University of Sydney and currently used at Lanzhou tends to satisfy the needs of the traditional style of knowledge-focussed education where many facts must be known by rote (memorisation and recall are emphasised). Teaching contact is comprised of lectures (70%) and practical classes (30%) and compulsory fieldwork during the semester breaks; there are no seminars, tutorials, web-aided instruction, etc. Lectures, fieldwork and other classes are very much teacher-centred activities (Table 2). Teachers carefully select texts, prepare and present lectures using old-fashioned delivery technologies; classrooms are always overcrowded, laboratories are overwhelmed, and field trips unfold like invading armies. Students are seen by their teachers as empty vessels to be efficiently filled with scientific knowledge. Consequently they tend to 'learn' science by memorising and understanding the body of facts in a discipline and reinforce their knowledge with many examples, exercises and tests, and then apply these facts to a task. This approach has served well in the past but requires that students have an interest in geology

Table 1. The comparison of current geology curriculum system

	Lanzhou University	**The University of Sydney**
1st year	General Geology Crystallography and Mineralogy	Earth and its Environment Earth Processes and Resources
2nd year	Petrology (igneous, sedimentary, metamorphic) Paleontology Structural Geology	Plate Tectonics and Materials Geological Exploration and Resource Management Fossils and Time Environmental Geology and Global Climate Change
3rd year	Geochemistry Geophysics Ore deposits Environmental Geology Oil-Gas Geology and Geochemistry Geomorphology and Q-geology	Structural Geology: The Dynamic Crust Geophysics, Imaging, Oil/Ore Production Regolith-Sediment Geochemistry Mineral Deposits and Spacial Data Analysis Remote Sensing: Imaging the Earth Field Geology and Geophysics
4th year	Elective courses and thesis	Honours students

and earth processes to begin with; being able to just remember those important facts and concepts that are probably not too useful for them. On the other hand we all recognise that the day-to-day practice of a geologist requires practical skills, problem solving skills, communication skill, lateral thinking, leadership and interpersonal skills and an innovative frame of mind. Student-centred teaching and learning strategies such as contemporary education theories, strategies and approaches can be used to foster students' interests in geology.

Applying contemporary education methodologies at Lanzhou

Teaching styles can be divided into three groups: discipline-centred, teacher-centred, and student-centred (Dressel and Marcus 1982; Woods 1995) and none of them is particularly better-suited for teaching geology than the other. The constructivist theory (Piaget 1972; von Glaserfeld 1989), problem based learning (Auit 1994; Smith 1995), concept mapping or 'schema' construction (Anderson 1977; Novak 1990), inquiry-based teaching and learning (Brew 2003), case study and the practice of learning (Wilson 1996) etc. contemporary education theories, strategies and approaches have appeared to dominate a view of learning articulated in the educational literature and have one common idea: student-centred teaching and learning is widely accepted to be a better approach than teacher-centred ones.

Student-centred teaching and learning strategies resulted from research launched by American institutes of higher education during the 1970s and led to the formation of systemic theories of the student-centred teaching and learning strategies by the 1990s. These strategies could be employed to address the problem of diminishing numbers of students taking science-related disciplines. To keep students in our classes our teachers need to think about how students learn and make the students actively involved in the teaching process.

The constructivist theory

Constructivist theory has been one of the latest catchwords in higher education in recent years. It not only emphasises active and collaborative learning, but also requires students and teachers to discover and construct knowledge together. The process of quality teaching and learning involves the constant construction and reconstruction of knowledge, the motivational context and the importance of deep level processing of knowledge, the construction of knowledge is an ongoing and continuous process that must actively involve students. Student's activities are active rather than passive, less emphasis on knowing but more emphasis on working things out for themselves, and have the final responsibility for their own learning and evaluate themselves. The learning outcomes depend on the knowledge, the purposes, the motivations and the beliefs.

As a consequence constructivist theory can be applied in lecture to give students greater autonomy (Independent Learning) and to emphasise the motivational context of human learning (Personal Development).

Problem based learning

Problem based learning (PBL) is a curriculum development and delivery system, which recognises the need to develop problem-solving skills as well as the necessity of helping students to acquire necessary knowledge and skills by utilising real-world problems that may not be solvable, but nevertheless provides a rich environment for learning. PBL almost always employs groups of students working co-operatively, sharing ideas, dividing up the learning to be done, briefing each other and solving problems co-operatively, learning is integrated, self-directed and occurs in the context in which the knowledge and skills will be used. The process of struggling with actual problems is to learn rather than to solve the problem, when students identify problems, formulate hypotheses, conduct data searches, perform experiments, formulate solutions, and determine the 'best fit' of solutions to the conditions of the problem, students develop critical thinking, problem-solving, collaborative skills in addition to content knowledge (Auit 1994; Smith 1995). PBL can be a powerful method for integrating academic and professional knowledge, and can provide interactive and cooperative learning.

Concept mapping

Concept mapping ('Schema' construction) which derives from constructivism theory is a technique for representing knowledge in graphs. Knowledge graphs are networks of related concepts that are interconnected, in which various forms or lists of information are classified and their links

are shown. Usually, a concept map consists of nodes (points/vertices) and links (arcs/edges), nodes represent various related concepts within a topic, and links represent the relationships between concepts (Lanzing 1997). Words are used to label the links in order to depict the relationships more explicitly. So, concept mapping could be employed in tutorials to design integrate/complex structure (long texts, hypermedia, large web sites, etc.), to aid learning by explicitly integrating new and old knowledge, to communicate complex ideas, to reconstruct knowledge, to generate ideas (brain storming, etc.), and to assess understanding or diagnose misunderstanding.

A reinvigorated geology curriculum

Modern tertiary educations pay attention to teaching and learning ideas, theories, strategies, approaches and methodologies in order to improve the learning. Deep quality learning should be student-centred, cooperative in nature rather than competitive, should emphasise critical thinking skills, problem based learning, inquiry-based study and be personally challenging. Students need to be able to make creative use of the scientific knowledge and to solve problems, to analyse data, to interpret underlying trends or causes, and to write reports (Gibbs 1992; Chin and Brown 2000). The modern geology curriculum system should been designed on student-centred teaching styles to meet student's need and interests, each course should focus on a special issue or problem and different skills. For example, the current geology curriculum system of The University of Sydney (Table 1) has been designed to hold students' interests and to equip them with a variety of skills rather than to simply fill them up with concepts and content. It aims to expose students to a deep-learning environment, involve them in a community of learners, to cultivate practical skills, to enhance students' learning ability by applying course knowledge to real-world problems; and to encourage the student-centred learning process and team-work as the cooperative learning.

By applying constructivist theory and using problem based learning, concept mapping, case study etc. we can embrace contemporary education strategies and approaches. If we do this our teaching styles could be changed from a traditional style to modern teaching style (Table 2). In this model a student-centred focus dominates the whole teaching and learning processes. By using relevant strategies and approaches, our teachers will have successfully fostered a high-quality learning environment and will provide students with the range of skills they need for the workplace.

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Table 2. The comparison of the traditional and modern teaching styles and strategies

	Traditional teaching styles	**Modern teaching styles**
Lectures	70%, teacher-centred	50%, Delivery Technologies and Teaching Techniques, Interaction in Class, constructivist
Practices	30%, teacher-centred	50%, problem based learning
Tutorials	none	concept mapping
Web-based	none	inquire based learning
Field work	teacher-centred	student-centred, problem based learning

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