

The use of a constructivist teaching model in environmental science at Beijing Normal University

Ye Zhao

Department of Resource and
Environmental Science
Beijing Normal University
Beijing 100875
People's Republic of China

zhaoye@bnu.edu.cn

Abstract

Constructivist theory has been one of the latest catchwords in higher education circles in recent years. It not only emphasises active and collaborative learning, but also requires students and teachers to discover and construct knowledge together. This paper analyses the characteristics of environmental science and the teaching methods of Beijing Normal University, and discusses how to use constructivist teaching models in environmental science teaching. This paper will show: that during teaching and learning in environmental science, both the concept map and mind map are useful tools to promote active learning and the students' abilities to integrate knowledge; and that problem-based learning (PBL) and the use of case studies can effectively motivate students' learning curiosity and develop creative abilities. It is argued that constructivist teaching models and perspectives can improve environmental education reform in Chinese universities.

Introduction

Traditional teaching and learning is the process of the transmission of knowledge from teacher to student. It is essentially a one-way process. Most students arrive at university with an expectation of a 'mug and jug' approach to education by their teachers, i.e. the students represent empty mugs to be filled up with knowledge from the teachers' jugs. This teaching method can hinder the development of individual student's active and creative abilities, and students who experience only this model of education may no longer be considered sufficient for the needs of a future educated citizenry. Constructivism is basically a theory about how students learn. Fosnot (1996) has provided a recent summary of these theories and has described constructivist teaching practices. This work shows that students learn by fitting new information together with what they already know. This theory has been one of the latest catchwords in higher educational circles during recent years (Crowther 1997; Dougiamas 1998). The constructivist teaching models have been widely used in teaching and learning sciences in universities (von Glasersfeld 1991). Constructivist teaching models not only emphasise active and collaborative learning, but also emphasise students and teachers discovering and constructing knowledge together. It presents the students with opportunities to construct new knowledge based on their prior knowledge and understanding from previous authentic experiences. Such prior knowledge is often referred to as a 'presage variable' and represents the different backgrounds, experiences and knowledge bases that students bring with them to the learning situation. This approach encourages students to confront real world problems which are within their everyday experience. The characteristics of constructivist teaching models include: prompting students to observe and formulate their own questions; allowing multiple interpretations and expressions of learning; encouraging students to work in groups; and in the use of their peers as resources to learning.

Because everyone lives in the natural and built environment, everyone has some knowledge of these environments. Based on the constructivist theory, everyone therefore has the background and the potential ability to learn about and acquire knowledge of environmental science. Constructivist teaching models can therefore be a very useful approach to teaching environmental science. This paper represents our collaborative effort of the teacher educators of the University of Sydney (USyd) to use the constructivist teaching models in environmental science at Beijing Normal University (BNU).

The development of environmental science at BNU

Thomas Pritchard first used the concept of environmental education (or environmental science) at the meeting of the International Union for the Conservation of Nature and Natural Resources (IUCN) in Paris (1948). Four years

later a meeting of IUCN's Education Commission (1952) called for environmental education to be established as a discipline, both in schools and in institutions of higher education. The 1968 UNESCO Conference called for the development of curriculum materials relating to studying the environment at all levels of education, the promotion of technical training and the stimulation of global awareness of environmental problems. However, the classic definition of environmental education was formulated at the IUCN/UNESCO's International Working Party Meeting on Environmental Education in the School Curriculum in 1970 (Palmer 1998). It was agreed and adopted that environmental education may be seen as:

the process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the inter-relatedness among people, their culture, and their biophysical surrounding.

It was in the United States that the development of an environmental education research agenda gained momentum during the late 1970s, and the studies of the researchers at the University of Southern Illinois had significant impact upon European, Australian and Asian environmental education curriculum development and research.

Beijing Normal University (BNU) is a Chinese University that is at the forefront of environmental sciences and is a leader in developing environmental science education in Chinese universities. Supported by UNEP/UNESCO in 1978, BNU began to train Chinese teachers and researchers for environmental study, and Professor Peitong Liu, etc. of BNU then established and taught courses in environmental science for undergraduate and graduate students of the Department of Geography. In 1982 he formulated the definition of environmental science in Chinese. The definition is translated as follows:

environmental science is the interdisciplinary science that aims to explain the structure and dynamic processes of environmental systems, to adjust the interaction between man and environment in order to improve environmental quality.

This definition was formally adopted and recorded in the Chinese Encyclopedia. During the early 1980s, Professor Liu and other teachers published Chinese textbooks for use in Chinese Universities, e.g.

- *Introduction to Environmental Science;*
- *Introduction to Environmental Protection;* and
- *Principle of Environmental Impact Assessment.*

The author of this paper still makes use of these texts in teaching environmental science to third-year undergraduate students at BNU.

Environmental science aims to give students a broad perspective on the ways in which different aspects of our environment interact, whilst also providing students with the relevant skills to become effective environmental managers. However, in order to become better environmental managers, students must rely on their understandings and knowledge of the natural and technical

sciences as well as their knowledge of aspects of the social and humanistic sciences. It is in the combination of this integrated knowledge that we may establish and develop the tools for a wiser study and management of the environmental problems of the future. (Watt 1973; Mather 1995).

Today most environmental science instruction and curricula in Chinese universities are based on a didactic model of teaching and learning, i.e. one-way transmission and student absorption of information. Students are expected to passively receive and absorb an environmental science knowledge base and remember theories which are recorded in textbooks and in the thematic plan of an individual teacher. It can be argued that it is illogical to expect that these very traditional teaching methods will be effective in teaching a young, dynamic and immensely complex and integrated discipline like environmental science.

The constructivist epistemology assumes that students construct their own knowledge on the basis of interaction with their world and communication with their teachers. Over the last two decades the constructivist perspective and its associated teaching strategies have emerged as prominent approaches to the teaching of sciences at both high school and university levels. Significant amongst such teaching strategies are the use of: concept and mind mapping techniques; problem-based learning approaches; and case studies in understanding integrated real world issues and examples. Constructing concept and mind maps help students understand the linkages between concepts and ideas and their relationship with other interdisciplinary knowledge bases (the multiple intelligences of environmental science). It promotes the development and abilities of students to integrate a range of scientific knowledge, facts and theories which may be drawn from a range of different but inter-related disciplines. The use of problem-based learning and of case studies focuses on providing students with the opportunity to become active and collaborative learners as they engage with real problems which may or may not have clear cut answers and with real world examples of how such problems have been approached and solved, or partially solved, in the past. Such approaches intend to develop student's inquiry and creative abilities, and inform and instruct students about how to learn and to study environmental science in the future, i.e., to provide and develop lifelong learning skills.

The use of constructivist teaching models in environmental science

Concept mapping for teaching and learning environmental science

The concept map is a technique for representing knowledge in graphs; it is a very useful and effective tool for geography students to learn geographical sciences. The concept map can help students integrate new knowledge with old knowledge, to design and articulate a structure of the knowledge that they have learned, and to communicate complex ideas. Consequently, this teaching method can effectively operationalise a constructivist epistemology. A real understanding and appreciation of environmental

science issues relies on the bringing together of knowledge and ideas from a range of different academic fields. This in itself, is simply too much and too broad for teachers to contemplate teaching by a strictly ‘mug and jug’ didactic teaching approach. In order to improve the quality of Environmental Science Education in Chinese universities, future teachers could usefully incorporate the use of concept and mind maps in teaching their courses. This approach can significantly assist the student’s learning process towards: (a) sense-making; (b) the ability to add and synthesise new information within existing knowledge structures; and (c) adjusting prior understandings to new experiences.

In constructing concept maps in environmental science, teachers need to be acquainted with the knowledge their students bring with them to the learning situation. This is a necessary step according to constructivist theory and principles, because old knowledge and experiences are important in that they are the starting point upon which new knowledge is developed and new conceptual schemas are formed. For example, when teachers instruct on the concept of the environment (‘environment’ is seen as the total of the factors which affect the life of humans which include the sun, technosphere, atmosphere, biosphere, hydrosphere and lithosphere) we can use the concept map to help students understand this complex set of relationships and interactions. This broad concept map of environment might be viewed as having five nodes. The interaction between humans and each of the nodes is probably too complex for students to understand fully at an early point, and there are also very many linkages between each of the nodes which are equally complex and difficult to understand. Whilst recognising this, the power of establishing the fundamental interactions and relationships in the minds of the learners is still seen as being of enormous value. An outline of such a map can be found in Figure 1.

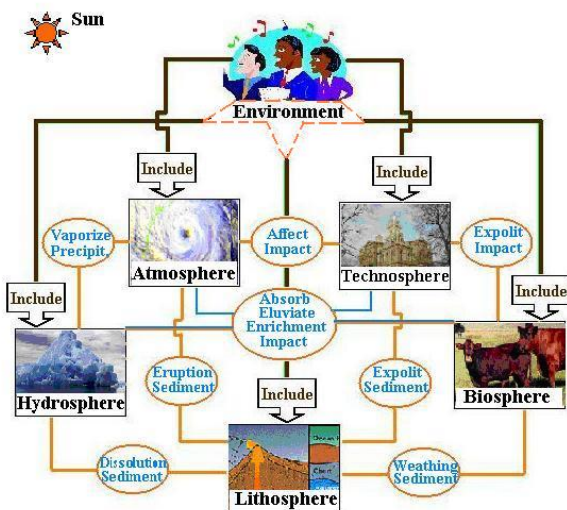


Figure 1. Concept map of the environment

We should use the knowledge of the associated disciplines of geology, meteorology, climatology, hydrology and ecology that the students have gained during their first and second years of study to assist their understanding of the relationships and linkages that are demonstrated in the concept map. We should encourage students to use their

own observations and life experiences to make sense of this map and understand the complex relationships and interactions. This teaching approach, it is argued, will motivate the students’ interest in learning environmental science as they will see it as a dynamic study which is relevant to their lives and to their future. Their own active involvement in the determination and understanding of this complex set of ideas and interrelated disciplines will inevitably encourage their own creative thought processes and observational abilities.

Mind mapping for teaching and learning environmental science

The mind map is a tool that helps students think and assimilate new knowledge and develop new and more complex conceptual schemas. It consists of a central idea to which related concepts are linked. The map consists of the central large idea and the 5 to 10 main secondary concepts that relate to it. You then take each of those concepts and again draw 5 to 10 third level concepts that relate to each of them. The difference between a concept map and a mind map is that a mind map has only one central idea in it but a concept map can have several linked concepts and should demonstrate the interrelationship between a range of powerful ideas. During teaching and learning, a mind map cannot only help teachers teach their students’ such things as creative writing, communication skills and the ability to integrate knowledge and related ideas, they also help teachers to explain why they are focusing on a particular aspect of a topic.

From the mind maps that students make, teachers may learn whether their students understand the topic and whether the student is able to organize and construct a suitable structure for that knowledge. So it is a very useful tool for the teaching of environmental science and also as a powerful device for the student in constructing a framework for making sense of that knowledge. The knowledge base of environmental science has proved difficult for students to comprehend, for a number of reasons. Firstly the content knowledge base that environmental science addresses is extremely wide-ranging and incorporates a bewildering array of information. The content typically incorporates aesthetic, spiritual, social, political and economic dimensions alongside the purely scientific. Secondly, the content is dynamic and ever changing, and it is also characterized by highly complex interrelationships, priority problems, causes, impacts and solutions. Therefore, it is important, effective and useful for students to structure their understanding of environmental concepts in a way which can help the students to be effective note takers and which can generate new ideas and associations that they have not thought of before.

Teachers should also encourage students to make a mind map of specific information that they are studying. This will assist the students to know what it is they have learned and what it is they still do not understand. For example, the students of my environmental science classes have been living in Beijing for two years; they have learned something about the environment of Beijing. They are encouraged to make mind maps of the issues concerning air pollution in Beijing City, as shown in Figure 2.

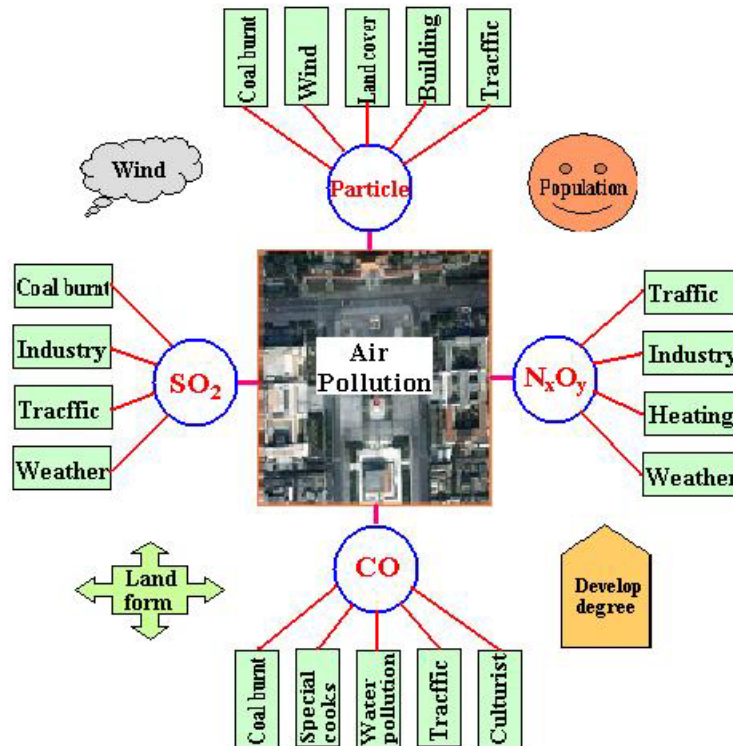


Figure 2. A mind map of the air pollution in Beijing City

During the construction of these mind maps, some students believed that winds import many polluting particles to the air of Beijing, others think that winds often purify the polluted air of Beijing. Clearly they need to observe, experiment, analyse and discuss for this question to be resolved. In this process, students come to understand that one person's solution may be another's catastrophe in learning. Students should be made to actively engage in understanding the beliefs of others and have the skills to resolve the contentious issues and ideas between themselves.

Problem-based learning with case study for developing the student's skills

Problem-based learning (PBL) is both a curriculum and a classroom process; the curriculum consists of a set of real world problems that demand the students' acquisition of critical knowledge, problem solving proficiency, self-directed learning strategies, and team participation skills; the classroom process replicates the commonly systemic approach to resolving problems. So it is argued that PBL can motivate students to identify and apply research concepts and information and also to work collaboratively and communicate this information to each other effectively. It is a strategy that promotes lifelong habits of learning. Palmer (1998) thinks that environmental science teachers should pay attention to the students' communication and information that results from living and interacting in a particular locality and community. It is obvious that PBL plays an important part in teaching environmental science. When teaching environmental science, we present many complex real world problems, often as case studies of real events (as depicted in Table 1). These case studies not only provide practical models to be copied if successful, or

avoided if not, but also provide a form of reality check. This is particularly useful in an interdisciplinary field such as environmental science where there are multiple realities and in which rhetoric and recommendations abound. Additionally, in such a field as environmental science, much of the literature refers more to potential than to practice. Perhaps most importantly, at least from an academic perspective, case studies provide a basis for analysis in any field where predictive theory is weak and testable hypotheses are wanting, including such complex areas of human social behavior as environmental science.

Whilst most students are acquainted with these problems, teachers still need to supply the appropriate papers, books, CD-ROMs and Internet sites that are related to these problems. This is necessary to scaffold students' learning within informed and reliable information sources. The teacher may then form problem solving groups, based on similar learning interest. Each group should be about 5 to 7 students strong. Each group of students might select their own problem of interest, read and analyse relevant documents and materials, organize their new ideas and learning with their previous knowledge related to the problem. They should be encouraged to discuss the problem between themselves, make a study plan, construct surveys and relevant samples as they relate to the problem, measure and analyse the samples, then use an appropriate reporting procedure to create dialogue on the topic. The holistic learning process of PBL in association with case study is shown as Figure 3.

Having taken part in this process, students in groups understand how to use their existing knowledge to solve real problems, and how to learn new ideas and concepts, how to develop their learning abilities in the future.

Group	The case studies (real-world environmental question)	Special demand
1-5	What are major factors affecting the water quality of Yuehe River in Beijing City?	Demand to sample and laboratory work.
2-6	What is the effect of the wastewater from Yanhua Company on the agriculture?	Demand to sample and laboratory work.
3-12	What are the effects of the geographical factors on the atmospheric environment or the water resources of Beijing City?	Be familiar with the geography in Beijing and GIS.
4-5	Which factors are important in minimizing the environmental impact in Xiangshan Part of tourism: technology, education, client-selection and management?	Be familiar with Xiangshan Part and its tourism.
5-8	What is the effect of population growth on the environmental degradation in China?	Demand reading in Library and Internet

Table 1. Some case studies (real world examples) for PBL in environmental science at BNU

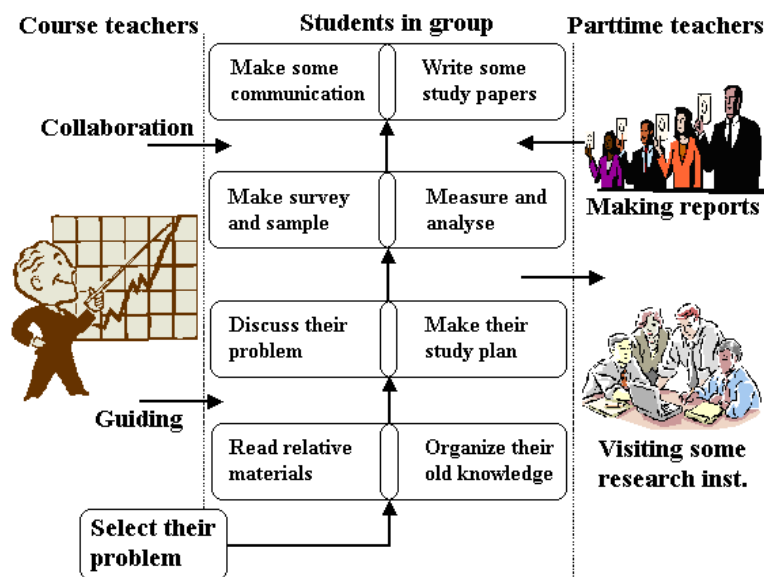


Figure 3. The learning process of the PBL with case study in environmental science

Conclusion

Constructivist pedagogy necessitates respecting students' ways of learning and incorporating them into the educational processes we utilise. By using concept and mind mapping methods, the students' active and collaborative learning approaches are emphasised, and their skills of sense making and knowledge integration within a multi-disciplinary subject are developed. By using PBL in association with case studies, the student's learning curiosity is engaged, they are more motivated to identify the concepts and principles. The skills of acquiring, communicating, organizing information and writing abilities were also developed. In active and collaborative learning settings, the roles of the teachers have been changed, teachers become the guiders or collaborators in the students' learning, i.e. they play the roles as 'guide on the side' not 'sage on the stage'. The constructivist teaching models, if used in the teaching of environmental science, can give the students a broader perspective on the ways in which the different aspects of our human environment interact with each other, and provide the student with the relevant skills and abilities to become the effective environmental managers of the future which are so urgently needed.

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