

# Improving the Curriculum: Introducing more Student-centred Teaching Strategies into the *Tectonic Analysis* Course

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## Introduction

*Tectonic Analysis* is a sixty-hour long course that is required for postgraduate students intending to major in structural geology and tectonics at the China University of Geosciences (Beijing). This course has been delivered since the autumn of 1998. In addition to the structural geology and tectonics majors, students from other sub-disciplines of earth sciences take the course as an elective course. These students generally have a background in petrology, sedimentology, ore deposit geology, petroleum exploration, geochemistry, seismology, geophysics or palaeomagnetism. The total number of students taking this course has ranged between 25 and 35 of whom around one-third are structural geology and tectonics majors.

One of the most important aims of the *Tectonic Analysis* course is to equip students with the methods and skills of integrated analysis that enable research into tectonics and structural geology for both pure and applied purposes. It is assumed that the students have taken related courses to undergraduate level; these are structural and tectonic deformation, sedimentology, petrology, geophysics and geochemistry.

## Current course structure

*Tectonic Analysis* is comprised of four parts: lectures (36 hours), self-directed laboratory exercises (12 hours), individual oral presentations (6 hours), and a review paper (6 hours). The oral presentations are normally given as a review of self-directed laboratory exercises.

### Lectures

Lectures currently form the main component of the course. Their emphasis is on introducing the important concepts and theories of the sub-discipline to students. They tend to focus on the origin, evolution, development and problems of these concepts and theories, which form the basis of the sub-discipline and are very important for the student's future research and work. It is often necessary to spend quite some time on clarifying the misunderstandings and misuses of some concepts, which have arisen in their translation from the original English sources. Meanwhile these lectures prepare the foundation for the students' self-directed activities.

### Self-directed laboratory exercises

There are two major components of this required work, teacher-delivered material and student-created material.

### Teacher-delivered material

Students are required to analyze two geological maps, which have been simplified from real-world examples and answer sets of questions about the maps. The first map is relatively simple and contains additional material to help the students solve and answer the questions. In addition to the structural and tectonic information, there is topographical, geochemical and geochronological information. The second map consists only of fault traces. There is no topographic, rock-type or geochronological information. The questions for this map are open-ended. Students need to make reasonable assumptions in order to generate a solution to the question. This map interpretation requires them to integrate knowledge presented in lectures with knowledge they have from other areas of the earth sciences while keeping the regional temporal and spatial framework in mind. Students who have taken this course view this practical work as an important and necessary challenge from which they benefit greatly.

### Student-generated material

In this component of the course students have to create a hypothetical geologic map by themselves. Their map must satisfy a number of requirements including the

representation of at least seven different geological events (e.g. sedimentation, volcanic eruption, plutonic intrusion, folding and faulting deformation, and geological response to vertical crustal movement). In addition to preparing a map students are also required to: present a cross-section diagram. This must demonstrate and explain the sub-surface structure of their map area, as well as depicting the interrelationships of the different geologic units that occur in the map. In addition the students must write an essay that describes the geological history of the map area and give a 10-15 minute oral presentation that summarizes the geological evolution of their hypothetical terrain. These presentations form the third compulsory component of the course and are dealt with specifically in the next section.

### ***Individual presentations***

On completion of the hypothetical map students must give a presentation about their geologic map. Students must attend all of these presentations and are required to participate in a question session at the end of each talk. Each student can therefore expect to receive quite a varied number of questions, suggestions and comments from the other students and the course coordinator. Commonly students present confidently to their audience with plausible explanations and interpretations only to have them collapse under the combined scrutiny of the class. To their dismay the map and cross sections do not support their ideas or speculations. Impressively, these students often go back to the drawing board to revise and even re-compile their map without any pressure from the course-coordinator. These maps are then consistent with the original intent.

Written feedback on the course from students indicates that they benefit greatly from this process and the presentation – despite their sometimes intense disappointment. This experience of peer-assessment sharpens the presenters understanding and the audience's skills of analysis and review.

### ***Review paper***

Towards the end of the course, students are required to write a review paper on the latest developments in a research field. They choose a topic, from a list provided, that appeals to their interests and discipline. Students can also choose their own topic if none on the list appeals to them and are assisted in locating relevant papers in the appropriate major journals. Most of the students perform well in this project but unfortunately there is not usually enough time left to discuss their work in group sessions. The quality of the review is taken into account in the assessment of their performance in this course. Some of the more outstanding reviews are published as papers in the relevant Chinese journals.

### ***Assessment***

The assessment on students learning is based on the performance of students at all stages of the course. There is no formal examination or test. Before a mark is returned students are asked to provide a written self-assessment on their own study. Students provide us with two marks for their self-assessment, one is a score that indicates the mark the student thinks they should receive and the second is a score that indicates the mark that they expect to receive. An

interesting aspect of this process is this, each time there are some students whose first score (the should-score) matched the instructor's assessment almost exactly. But these students generally either overestimate or underestimate the second score (the expect-score). As part of the assessment process students are also asked to make suggestions as to 'How the course could be improved'. Interestingly the more valuable suggestions usually come from the students whose 'should-score' is close to the course-instructor's score.

## **Perceived problems with the current teaching of *Tectonic Analysis***

Although there has been some attempt to make this course more student-centred it is predominantly a teacher-centred course. The predominance of lectures means that less than half the course contact hours involves student-centred teaching. It is our experience that students who have a good working background with relevant experience usually do much better in this course than those who have just finished their undergraduate degree. Many of the newly graduated students would prefer the instruction to be entirely teacher-focused because they are accustomed to teacher-centred, lecture-dominated teaching and learning. They tend to struggle with the literature review and map compiling projects and try to involve the teacher in their work more than they should.

Similarly, there is no groupwork in the course despite the fact that the range of experience of the class members would make this approach suitable. Currently, there is little opportunity for students to learn from each other except in the presentation sessions. They work individually or with a teacher. Neither team work nor group discussion occurs in the course. This absence of groupwork is an obvious limitation as it prevents synergy developing between the students. We should be allowing the students to take advantage of the diversity of disciplines they come from.

Finally, and possibly most importantly, it is not clear that the students leave the course well enough equipped with lifelong learning skills. While some of the students do leave the course as good independent learners and knowledge acquirers these skills are not as developed as expected in some of the other students.

## **Reasons for choosing this course to test some different approaches to teaching**

Student-centred teaching and learning strategies are virtually unknown in China while they are commonly used in undergraduate and high school education in many western countries. It might seem to many that it is too late in the educational process to introduce this type of change into a graduate course and that we should be reforming our junior courses. However from our knowledge of Chinese undergraduate students we think it is a reasonable thing to test new ideas, approaches and, strategies on more mature students and then apply those things that succeed at more junior levels. The main reasons for this caution are:

- a) Introducing student-centred approaches and strategies, such as problem based learning, case studies and inquiry-led methods, is a time consuming and labour intensive process. Whilst it is not possible to stop or postpone other courses to develop new materials (so that we can apply different teaching methods or a new teaching strategy), trialing a strategy with a small number of committed learners (postgraduates) might be more achievable.
- b) At this stage improved outcomes can only be expected when the students involved have sufficient background knowledge, given that any course of study must be finished in a limited time period.
- c) The implementation of student-centred teaching strategies or approaches in our classrooms requires profound reform of administrative policy. The allocation of teaching and research resources will also have to be adjusted appropriately to facilitate any reform of teaching practice. This will have major consequences for class, laboratory and library timetables, assessment of student learning, evaluation of teaching effectiveness, promotion policy and so on.
- d) Teachers who are going to implement new ideas within their existing teaching will have to spend a great deal of time to prepare themselves to be able to change from being a knowledge-transmitter to a learning-supporter, and to extend their own knowledge of teaching practices generally.
- e) Finally, but not of the least importance, no matter how good an idea seems to be at its conception, we want to be sure that it will succeed in its application. As a European proverb puts it 'The road to hell is paved with good intentions'. You, as the teacher will have many more opportunities to test your new ideas and thoughts if they don't work out to begin with, but for the students, they have only this one opportunity to study your course. If your reforms fail then you might damage their careers or lose potentially great scientists from your academic field. On the other hand, if your reforms are successful they will probably breed further success.

With these thoughts in mind, we feel that reforming slowly in a course where there is a great likelihood of success is the appropriate choice.

## How to achieving improvements in the *Tectonic Analysis* course

Experience in teaching the course and feedback from the students in the last few years suggests that the time used for traditional lecturing should be reduced and replaced with self-directed practicals along with modification of the curriculum. To achieve the improvements in *Tectonic Analysis* several activities are suggested – concept mapping, problem based learning and group presentations.

### **Concept mapping**

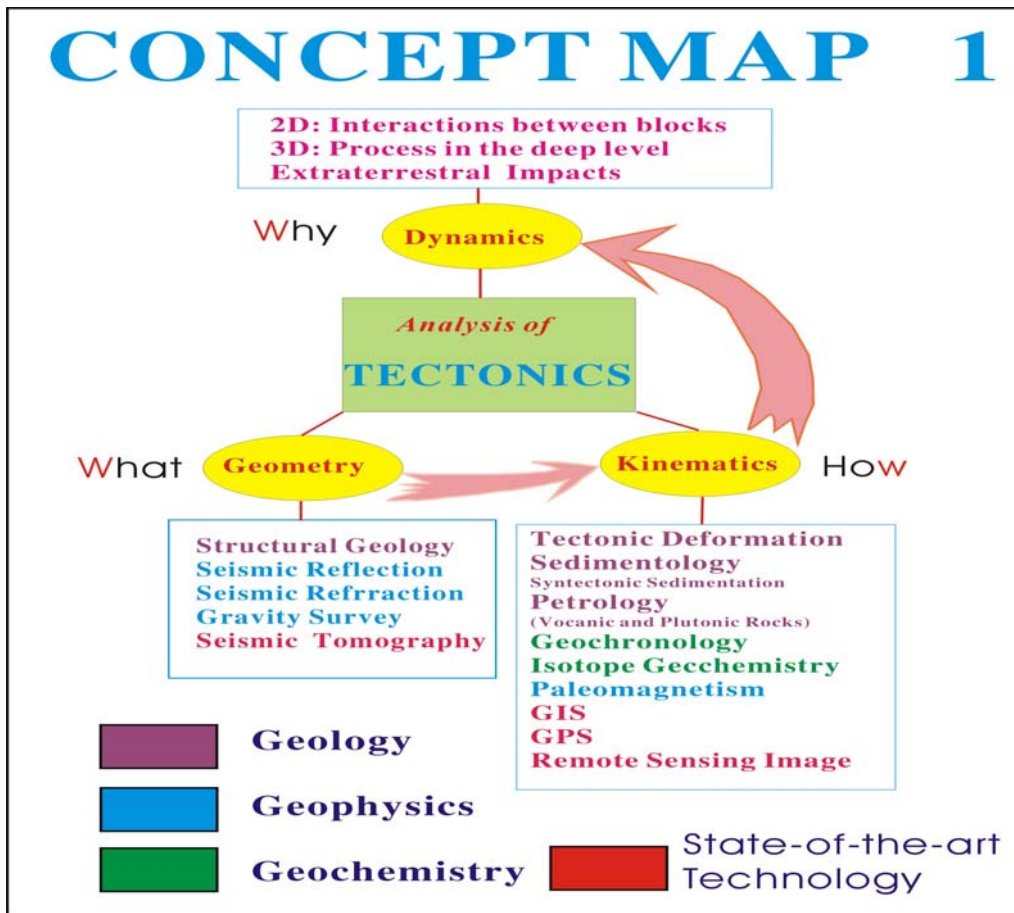
Students will be asked to construct two concept maps: one at the beginning of the course and secondly when they have completed the course. This concept mapping exercise is designed to help students build a knowledge framework and a mental connection between the main concept and subsidiary concepts in this field. This work will be carried out by students in groups in order to help students talk to one another and learn from one another during the mapping process. The pre-course (or beginning course) concept maps will be compared with the end of course concept maps. This is expected to show the students how much they have improved their knowledge through self-assessment and to make them more confident about their ability to learn. It should also help them to appreciate how one can learn from the learning process – which we think will be a significant improvement.

Two concept maps are given as possible examples of what students might generate. One is the 'What-How-Why' thought sequence given in Figure 1. It shows how students could probe the subject of Tectonics by developing an answer for the question 'WHAT is tectonic geometry?'. Students can then deduce the kinematics of tectonic events by answering the question 'HOW did the structure or structures form?' and, finally students could come to an understanding of tectonics by answering the question 'WHY did these events happen?'.

The concept map suggests that at least three major bodies of knowledge must be included in the course *Tectonic Analysis*. These are geometry, kinematics and dynamics. In turn each of these three bodies of knowledge draws on the areas of geology, geochemistry and geophysics. The entire system is built on the base of the geometry of tectonics. Consequently investigation in this system should start from this point. Students will also gain a first impression that integrating and synthesis is a main part of the course rather than learning about this process as a distinct or separate concept.

The second proposed concept map is focused on the spatial aspects of tectonics (Figure 2). From this map we can see that the entire system could be divided into a) surface or shallow-level tectonic processes and b) deep-level tectonic processes respectively.

Compared to the concept map in Figure 1 this second map seems more integrated and less hierarchical. If a concept map was constructed in this style and the teaching process follows this track it is difficult to see how better educational outcomes could be expected. However its utility might be increased if it was integrated into the other as part of the geometry, kinematics and dynamics subdivision.



**Figure 1.** A proposed concept map placing *Tectonic Analysis* at the centre of the system and showing the components and interrelationships of the major and other concepts.



**Figure 2.** An alternative concept map of *Tectonic Analysis*, built on spatial considerations

### **Implementation of problem based or inquiry based learning strategies**

Student-centred, problem based learning (PBL) strategies have been shown to be a powerful teaching tool in a variety of disciplines since their introduction in medical education by the Newcastle group in the 1980s. In PBL students are expected to become active learners while teachers are not the conventional knowledge transmitters but act as learning supporters. Students learn not only from solving the real world problem but also from the learning process itself. This helps students to develop their own life-long learning skills. These advantages inspire us to think of how they could be applied in teaching *Tectonic Analysis*. PBL strategy generally requires that a real world or real-life problem be solved as a motivation for learning about the content and concepts of interest. To some extent such a problem is difficult to pose for this course because a great deal of information is required before you can begin to grapple with it. Nevertheless it might be possible to use the geologically recent uplift of the Tibetan Plateau as a real world problem.

#### **Example**

**Scenario:** *During late spring and summer each year there always are many floods in India and Bengal. At the same time northwestern China becomes arid and the area of desert present there increases. Meteorologists tell us that this great climatic difference results from the presence of the nearby Himalaya Mountain System between the two geographically adjacent sites. The Himalaya is the highest mountain system in the world, with Peak Zhumulangma (Mt Everest) rising to 8848.42 metres above sea level (8850 metre, Nov. 1999). These mountains are known as the 'Roof of the World' and stop rainfall-containing clouds moving to the north of them, forcing them back towards the Indian Ocean so that they drop their water in India and Bengal during the yearly monsoon season.*

*Many years ago geologists found a sequence of strata of Cretaceous (135-65Ma BP) as well as rocks of younger age at the top of the Tibetan Plateau. The strata contain a lot of oceanic animal fossils. What does this mean? It means that at the time of less than 65Ma ago the current top surface of the 'Roof of the World' was located well beneath sea level. The uplift of the area, where the current Tibetan Plateau is occupying at present, has occurred since this time.*

**The task and the problem** for students is: *'How and why did the area known as the Tibetan Plateau come to be uplifted to its present day position?' That is – why is the Himalaya there and how old is it?*

In order to solve this problem, students must find for themselves the information and materials about the surface geology, the area's structural and tectonic deformation, the existing geochemical and geophysical data and their geological interpretation, the geochronological research achievements, as well as the recent seismic tomography results and GPS measurements. Considering this in the

context of the concept map given in Figure 1 it seems to us that this problem design could match the requirements of the course as a whole.

The biggest problem with this proposed PBL approach is the mismatch between the TIME NEEDED to solve the problem and the TIME AVAILABLE to solve it in. It is not currently possible to reduce the lecture timetable and self-directed practicals to provide sufficient time to this proposed use. Alternatively we could attempt to isolate small aspects of this larger problem and deal with them using inquiry-based teaching and learning.

#### **Group presentations**

Individual presentations are implemented in the current teaching of *Tectonic Analysis* at the China University of Geosciences in Beijing. This will be changed to group presentations once teamwork and group discussions are implemented into the new curriculum. In these new presentation sessions, each student will be asked to present the parts of the work that they were involved in. This format is expected to stimulate and improve the collaborative working skills of students giving them opportunities to learn from each other.

### **Perceived potential problems with this attempt at curriculum reform**

There may be many problems faced in attempting to introduce more student-centred teaching and learning strategies in this course. The greatest challenges include the problems associated during the transition from teacher-centred teaching to student-centred learning and insufficient time available for the transition.

Along with the implementation of a student-centred strategy in improving the teaching and learning process, students will have to change their role from listener and knowledge receiver to active learner, meanwhile, the teachers have to accept a change in roles from being knowledge transmitters to learning supporters. Both participants in teaching and learning have to adjust to their new roles. For teachers this could be a gradual process taken over several years. However, for the students who are currently going through our university system, they might only meet with this new teaching once during their university study and they may find this change difficult to accommodate. If this course is reformed in isolation it may come to be regarded as something of an idiosyncrasy. We must therefore be able to use the new *Tectonic Analysis* course as a model to assist change elsewhere in the university.

The problem of insufficient time affects both students and teachers as well. Student-centred strategies need both teachers and students to invest more time into the teaching and learning process. Students will have to find information and materials for themselves. From their point of view it will be much more time consuming than listening to lectures. Synthesising information and writing essays will also be a great challenge to students, especially for those who do not have the necessary background knowledge. Teachers will have to keep up-to-date with developments in

their own field and related fields in order to deal with the range of questions arising from students working on their own and within small groups.

In addition to the changes in classroom, reform of administration and assessment as well as the adjustment of teaching and research resources must be carried out.

## Conclusion

It will be possible and achievable to graft student-centred teaching strategies onto the traditional teaching processes currently used in *Tectonic Analysis* in the immediate future. Rather than give up the conventional teaching approaches and replace them with something completely new, the reform of teaching and learning intended will be an evolution rather than a revolution. Just as the old Chinese proverb says, 'You'll never taste hot Tofu if you aren't patient' which means that you will not achieve your goal if you are in too much of a hurry to reach it.

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From my point of view (corresponding author), it will not matter if these speculations I made here come true or not on my immediate return to the China University of Geosciences. I will be well on the way to improving my teaching. This is because I have started to think about how I could make this course better and more effective and more productive. Of course, it is the study and what I've learnt here at The University of Sydney in teaching and learning theory that will encourage me and enable me to do so. For this reason, among many others, I'd like to take this opportunity to express my thanks from heart to the program coordinators and respectful professors Mike King and Mary Peat, and English teachers June Hammond, Paul Millio, and my professional mentor Tom Hubble in the School of Geosciences who did really a good job for us. Acknowledgements also go to the teachers/professors in the

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