Using class exercises to actively engage students in Structural Geology and Tectonics courses

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https://meetingorganizer.copernicus.org/EGU2020/session/34759
Course Aims

By the end of the course, the student has acquired:

• a basic understanding of the processes involved in the development of crustal deformation structures, at the macro-, meso- and microscales;

• quantitative insight into the determination of deformation and strain, deformation history and paleostress state from the study of deformed rocks;

• the ability to recognise “structural styles” (associations of structures characteristic of specific tectonic settings) and an understanding of their development;

• insight into the features and processes that are important to consider in analyzing deformed terrains and in constructing tectonic models.
3rd year Earth Sciences Bachelor’s degree course GEO3-1307 Structural Geology and Tectonics

Programme and examination – total study load 200 hrs.

• 4 lecture hours per week: 2x2 hrs
• 4 practical (“lab”) hours per week = one afternoon mini-project team-of-two
• Weekly home assignments
• Total of 8 weeks: face2face and self study

• One intermediate exam (week 4), one final exam (week 9)
• Assessment and grading of the practical reports

Utrecht system of “Continuous Assessment”
3rd year Earth Sciences Bachelor’s degree course GEO3-1307
Structural Geology and Tectonics

Topics

• Tools for quantification:
  Strain measurement techniques, tensors and Mohr circles, strain in folds and shear zones
• Structures in the upper crust: fault patterns, structural styles
• Deformation behaviour of rocks:
  Brittle field
  Ductile field
• The anatomy of orogenic belts: from upper to lower crust, role of ductile deformation
3rd year Earth Sciences Bachelor’s degree course GEO3-1307
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The issue:
Constraints on classroom availability and (financial) limitations on the number of hours a lecturer is allowed to spend on a course (teacher load) make that we still schedule classical lectures.
Not the most effective way of making students learn.

The way out:
Interactive lecturing
3rd year Earth Sciences Bachelor’s degree course GEO3-1307
Structural Geology and Tectonics

Interactive lecturing in GEO3-1307

• Q & A in the class
• Real time voting using Mentimeter
• Regular breaks with “pictures of the day”, from the collection of the lecturer
• Class exercises (“enough talking by me, let’s do something now”)
Class exercises

- Typically 2 per lecture hour
- Well defined aim and task
- Making observations
- Application of a concept, equation, technique
- Time investment 3-10 min/exercise
- Discussion with fellow students encouraged
- Results discussed plenary via Q&A
Class exercises - examples I: Tools for quantification of strain

Class exercise 1.5: The R-f' method

Task 1: In a deformed outcrop, sketch an R-f' diagram for the deformed objects (Fig. 1a), and determine the original ellipticity R0 of the objects and for deformed objects (Fig. 1b) and convert R0 of the original state.

Fig. 1a: Deformed outcrop.

Fig. 1b: R-f' diagram.

Class exercise 2.4: Analysis of tension gashes

Task: To obtain insight into the geometry and meaning of tension gashes and their shear microstructure. The analysis of a shear zone (Fig. 1a) in a foliated rock has shown that the maximum instantaneous shearing strain (SSA) is oriented at 35° with the shear zone boundary.

Task: Answer the following:
   a) Make a sketch of the geometry of 2-5 sigmoidal (inclusion) tension gashes in Fig. 1.
   b) Is this an 'extending' or 'shortening' joint zone? Why?
Class exercises - examples II: Structural styles

Course "Structural Geology and Tectonics"

Class exercise 4.2: Development of a salt diapir - North Sea example

Task: Study the section below (from Ullman's classic paper) and see if you can distinguish between the following and preceding stages of the salt diapir:

\( \text{Zv} = \text{Zechstein (Permian)} \), \( \text{Tk} = \text{Tertiary} \), \( \text{Tk} = \text{Tertiary} \)

End: Analyse the section and describe the structures in a framework of "structural styles". Make sure you distinguish between observations and interpretations.

Course "Structural Geology and Tectonics"

Class exercise 5.6: Structural style of inversion tectonics

The figure below shows an interpreted cross-section through a pair of the Cordillera Central of the NW Argentinean Andes (after Carrera et al., 2006).

End: Analyse the section and describe the structures in a framework of "structural styles". Make sure you distinguish between observations and interpretations.
Class exercises - examples III: Deformation behaviour of rocks

Class exercise 7.1: Deformation density

Aims: To get an idea of the ratio of magnitude of the total length of deformation in a given volume

Tasks: Consider the Transmission Electron Microscopy (TEM) image of the lower defect (deformations) below (from NRQ). Assume that the thickness of the “film” is about 0.5 μm. Estimate the total length of deformation in 1 cm².

Class exercise 7.4: Modification of microstructures during deformation

Aims: To practice making microscopic observations in relation to creep mechanisms (part 2)

Tasks: Below, a light microscopy image is given of a deformed marble. First, give a short description of the microstructure of the rock. Then, note how the initial carbonate rock would have looked and indicate which aspects of your description may be related to modifications of the initial microstructure due to deformation.

Photo NRQ

Photo RAJ
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Class exercises...

- ...bring back the attention of the students (in case it was lost...)
- ...re-emphasize a topic just discussed (the power of repeating)
- ...train distinguishing observation from interpretation (essential skill)
- ...motivate to come to class (i.s.o. reading the book bat home)
- ...can be re-used when preparing for exams (helps learning)

The students feel engaged!
3rd year Earth Sciences Bachelor’s degree course GEO3-1307
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Course evaluation:
What are, in your opinion, the three best points of the course?

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Top 5 of points mentioned in the yearly course evaluation
(note: no evaluation carried out in 2019, not yet in 2020)
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Structural Geology and Tectonics

Course evaluation:
Quotes from students re. class exercises:

- fun assignments, train you in problem solving
- learn as you do
- active participation during lectures
- help make things clear
- really useful
- class exercises were awesome
- keeps you active, helps understand
- direct application of theory
- very handy
- very useful

- interactive, stimulates you to come to the class
- help mastering the subject matter
- make it easier to follow the lectures
- helps practising skills (making observations)
- immediate application of theory, helps understanding subject matter
- gets everyone's attention and makes lectures more diverse
- nuttig en leerzaam
- make you able to really understand the subjects
- make the lectures less boring
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Class exercises...

...are easy to implement
...require only limited investment, but result in good yield
...are fun for students and lecturer!

Why not make a shared data base with exercises from which we all can draw?
> EGU focus group Higher Education