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Implementation of supporting, practice-based learning activities in short geology and soil science modules in landscape architecture and natural resource management curricula

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Abstract

This study tested the use of practical exercises on campus made possible by recorded lectures as a means to create variation in basic soil science courses. Curriculum changes from one discipline to multi-disciplinary courses including soil science, geology, geomorphology, chemistry, botany, ecology, plant physiology etc. has increased the risk of subject matter overload in relation to time and textbook materials over the last decade. Soil science teachers and students expressed the need for re-introducing practical hands-on teaching and learning activities in order to achieve competencies in soil, site and landscape evaluation e.g. with respect to suitability for tree growth. Teachers on multi-disciplinary courses are encouraged to work as teams to ensure balanced teaching and learning activities and avoid overload of subject matter from competing disciplines.

Introduction

Until a decade ago teaching in soil science was central for most curricula established at the former Royal Veterinary and Agricultural University (except Veterinary medicine). Typically, it was a 9 ECTS course in geology and soil science following a 15-18 ECTS course in general chemistry and followed by several optional specialized courses. Now, the common basic course for all curricula has been replaced by smaller modules in different multi-disciplinary courses and representing a maximum of 7.5 ECTS, i.e. less than 25% of the previous volume. This has happened in the curriculum for landscape architect bachelor students. The teaching activities are now more abstract and virtual due to the reduction in allocated time. However, judged by course descriptions (e.g. NG1: http://kurser.ku.dk/course/nigk13008u/2014-2015) the intended learning objectives are the same as before. As a consequence teaching activities are now mainly lectures that tend to turn students into passive spectators. There are also theoretical exercises, but they are not well connected with the lectures, which leaves the students confused about the intended learning objectives and the summative assessment. New, condensed textbooks have been written to accommodate the curriculum changes, e.g. Ashman & Puri (2008), or can be a dense book chapter in a general ecology textbook, e.g. Chapin et al. (2011) Principles of terrestrial ecosystem ecology. These books are tailored for cross-disciplinary courses for students with no background in science, but there are various pitfalls. Either the textbooks include too many details, or have tacit assumptions of student qualifications. Such textbooks are only meaningful, if the students know the content already from other previous courses.

In short, for introductory soil science courses the frame has changed (fewer ECTS), the learning activities have changed (less field work and no laboratory work), whereas the learning objectives in some new cross disciplinary courses are ambitious to a level that could easily cover a full masters' degree:

The intended learning objectives (ILO's) with respect to knowledge, skills and competencies for the two courses on which I base this study are summarized in brief here:

> **Ecology and ecosystems science in relation to environmental economics (EESREE, 15 ECTS, master level – 1-2 weeks allocated to soil science):** *'Describe biogeochemical and soil processes...' ' analyse structures', 'make plans', 'communicate solutions'*
>
> **Naturgrundlaget 1 (NG1, 15 ECTS, bachelor level, of which 7.5 ECTS have been allocated to geology and soil science):**

- Kende centrale jordbunds- og geologiske begreber og terminologi
- Beskrive grundtræk i Danmarks prækvartære udvikling, karakteristika ved glaciale og Holocæne sedimenter.
- Kende til jordbundsdannende processer og beskrive dem.
- Beskrive jordbundens komponenter og deres betydning for jordbundens vandhusholdning og fysiske tilstand.
- Kende grundtræk af jordbundsfauna og -mikrobiologi.
- Beskrive naturlige processer der påvirker menneskeskabte terrænkonstruktioner.

The question is whether the realized learning outcomes will match the intended learning outcomes in these courses. The EESREE (http://kurser.ku.dk/course/nigk13008u/2014-2015) course is an introductory course in the master programme for environmental and natural resource economy. NG1 is an introductory course in the bachelor programme in landscape architecture. Both courses may also include elements of botany, plant ecology, systems ecology, and broad natural resource management aspects. This gives a strong competition for adding work load from each of the disciplines involved, since many teachers with different scientific backgrounds are involved. If one discipline chooses to overload the students, this may become a general trend, and the result may be a catastrophic overload of subject matter from the student perspective with no clear idea of prioritization according to the learning objectives. In the NG1 course this has been solved by splitting the 15 ECTS in two blocks, and giving up the basic chemistry that was formerly a prequalification for the geology and soil science part. According to Figure 12.1, two factors have changed without changing the ILO's: The teaching and learning activities (TLA's), the frame, and the students' qualifications.

It may be so, that course descriptions are so general that changes in actual course contents after reductions in ECTS are not visible. It also may be the case, that the teaching and learning activities become imbalanced due to content overload in cross disciplinary introductory courses. This is my hypothesis for why students often express disorientation and feel overwhelmed.

During spring 2014 I met the landscape architecture bachelor students in the follow up course (NG2) where I was also teaching some days, since the applied soil science is my field of scientific work. I saw that the students were interested and motivated, but generally unable to demonstrate

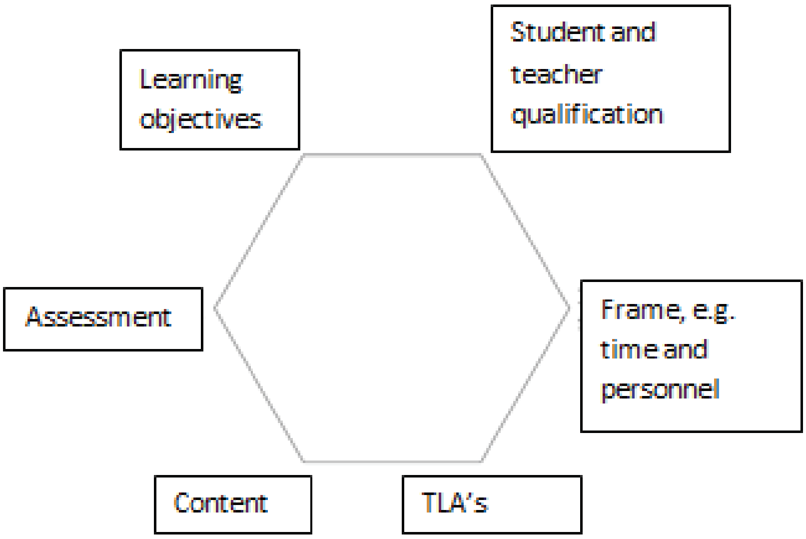

Fig. 12.1. The components of a teaching system in higher education. Modified from: 'Læring gennem oplevelse, forståelse og handling' (Hippe & Hiim 2002).

the competences they should have acquired during the NG1 course according to the ILO's. I realized the need for designing TLA's in the introductory courses that could match the needs for knowledge, skills and competences of the follow-up courses in the curriculum.

With this prehistory of a reduced time frame, one option for a teacher could be to give many lectures and present as much subject matter as possible within the very limited time frame in both courses. I did not believe that it would be a fruitful strategy. It would be better to plan the course content again by posing the question: "If natural science as a discipline is central for both these curricula, how can it be assured that most of the students get familiar with scientific method and creation of knowledge in the subject fields ?" They will be users of such knowledge in planning and designing landscape resources either physically or economically in their professional life. It became clear to me that practice-based experimentation and thus teaching and learning activities including this element are one of the main characteristics of scientific method and teaching in science. This is not mentioned in the course descriptions, rather it seems to be a tacit assumption, that student know how scientific knowledge is created.

Aim and problem

In this project I will investigate the implementation of practical exercises aimed at supporting active learning in geology and soil science taught in condensed course modules with long days (half day plus full day in the block structure) as part of cross-disciplinary courses. The intervention is to introduce practical exercises to students in two courses (EESREE and NG1) that were not intended to have them in the first place, that is, to include practical activation in teaching modules that could otherwise easily be filled with massive lecturing causing passive student behavior – the spectator syndrome (Herskin 2001). One of the issues in conducting practical exercises as group work is the demand for manpower. It will therefore be investigated whether learning outcomes are affected by the presentation order: Are audiovisual pre-recorded lectures a useful TLA in providing 'unmanned' teaching for one half of the class (65 students in total), while the other half is carrying out practical exercises ? Will the order of activities affect the learning outcome?

Pedagogical theory

According to the teaching system depicted in Figure 12.1, intended learning objectives, subject content, assessment methods and TLA's should form a harmonic system no matter the length of a course or module. Practical exercises are not required to meet a specific competence in the ILO's. It would be perfectly alright to lecture and ask the students to memorize concepts from textbooks and rephrase them for an oral or written exam. However, the practical exercises would be supporting activities in order to secure that higher education teaching with a constructivist approach is research-informed and may also be research-based at the basic level (Griffiths 2004, Butcher et al. 2006). The 'Learning by doing' is a well-known concept from scouting, sports, music and other training – and also in the academic curriculum such supporting activities are finding their place. Even though we are not training scientists in introductory courses, it should be clear how scientific knowledge is brought about. According to (Biggs & Tang 2011*b*, Table 4.2, p. 63), the notion that *doing* things supports the learning much more that *hearing* subject matter is attributed to the psychiatrist William Glasser (1925 - 2013).

The timeframe for my teaching did not allow for teaching scientific method and the experimentation behind the established accepted scientific knowledge (i.e. research-led or research-oriented teaching), and this was not the objective either. Instead I learned that *guided inquiry* is a method to mimic such activities; to train students in this mindset – how knowledge is created. A peer or the teacher shows some objects, and asks students to propose actions to explore and demonstrate a certain mechanism, concept or idea (Lewis & Lewis 2005). The teacher guides the students' recognition of a phenomenon and let them construct their knowledge by themselves.

Students can be trained to memorize and use textbooks and recapitulate them at an exam using a surface approach. In this context it is interesting whether the practical exercises can support a deeper learning and also when theory should be introduced – before or after the exercises.

Methods

1. **Pilot-study. Development and test of practical exercises**. During the EESREE course for fresh Master students of Natural Resource Economy one full day was assigned to soil science, which I was responsible for. I planned an intervention including 1.5 hours practical exercises involving observation and measurement of some soil properties (pH, texture, soil colour, bulk density, Appendix A6) from different land uses after an introductory lecture. After the day I asked the students to fill out a short survey to test their learning, their own impression of their learning, and their view of the different TLA's presented during the course.

2. **Survey among soil science teachers** on how to develop course contents from the previous 9 ECTS courses (+15 ECTS chemistry) with a clear focus on soil chemistry to shorter courses, e.g. in NG1 and EESREE with no further qualifications than the uptake criteria for the bachelor education in landscape architecture (Mathematics A and Chemistry C). With this survey, I wanted to get an overview of the different views on the changes and reductions, and retrieve inspiration how to design compressed geology and soil science subject matter teaching in the future.

3. **Intervention in TLA's on the NG1 course – theory or practical exercise first? Learning** landscape formation - the process of recognizing the dynamics and the time scale of landscape formation is a chal-

lenge for many students. I designed some hands-on exercises showing the action of glaciers (frozen 1 liter ice blocks with stones etc., see Appendix A7), water and wind on sediments as a background for analyzing landscapes and land forms in Denmark. The group of 65 NG1 students was split in two classes. One half first watched an audiovisual pre-recorded lecture, while the other half took part in an outdoor session in groups of four with hands-on small scale experiments in formation of the glacial landscape. The two classes switched activity after a short break. After the two TLA's the students took a short formative test in order to assess their learning. The use of a prerecorded lecture made it possible to offer the practical exercises with limited personnel and material resources.

Results

The following is a short summary of important outcomes from the three surveys included as appendices.

1. **Practical exercises for EESREE students**. Examples of the outdoor exercises are illustrated in Figure 12.2 and Figure 12.3. After the exercises the students filled out a questionnaire. 15 responses from 34 possible respondents were obtained. The students were asked how well they remembered a field excursion, some lectures and the practical exercises. The students clearly remembered what they did during the field excursion and the practical exercises and less so, what happened during the first morning lecture. However, the students remembered more content from the morning lecture than from the last lecture during the afternoon. They specifically selected field excursions and practical exercises as TLA's they would like to do more. When asking about the central learning objective, i.e. Jenny's conceptual state factor model for soil development, they remembered on average 3 (2-4, 95% confidence limits) of the 6 factors in the model. Three respondents remembered none of the model factors climate, organisms, relief, parent material, time and man. The latter observation was somewhat surprising to me.

2. **The soil science teachers participating in the survey dealing with basic geology and soil science in the NG1 course were asked the following questions (answers in Appendix, pages 10-20)**:

a) Are first year students with the mentioned background from gymnasium (Matematik A, Engelsk B, Fysik B og Kemi C) capable of using the chemistry they should know to study basic geology and soilscience as outlined in the learning outcome below (see page 1)?
b) Which topics are the easiest for students to learn - pick three
c) Which topics are the hardest for students to learn - pick three
d) Choose teaching and learning activities that would think are indispensable in meeting the learning objectives (choose as many as you like)
e) Given limited resources (time and personnel) choose three teaching and learning activities that can be discarded with only little loss in the students learning outcome?
f) Which of the below publications would you find suitable for basic teaching of soil science at university level? Please, rank the following textbooks in order of their suitability for basic teaching in soil science and value for money.
g) Which of the below textbooks (within the same 7.5 ECTS course) would you find suitable and choose for basic teaching of geology and geomorphology at university level for first year landscape architects? Please, rank (1-2) the following (see A2)
h) Students can choose their own textbooks according to the university reform. Is it OK to use and recommend material from encyclopedias on the internet to students?

I invited 17 soil science teachers and got 9 responses. The most univocal answers were that soil chemistry is the hardest topic for students to learn (Q2), and that field work is indispensable (Q3), whereas drawing exercises can be discarded (Q4). When it comes to choosing text books some of the short 'layman prose' textbooks currently used were given low priority in terms of suitability and value for money in comparison with more detailed textbooks, e.g. the standard American 800 page textbook (Brady and Weil: The nature and properties of soils). Also notable was, that the teachers participating in the survey disagreed in their answer to many questions, e.g. whether students have sufficient background from secondary school (Q1 50% said most, 25% some students had sufficient background).

3. **Intervention in the NG 1 course – development of practical exercises**.

The NG1 landscape architect students were split in two classes – one class received practical exercises with an intended ‘guided inquiry approach’ followed by an audiovisual lecture. The other class first watched the audiovisual lecture on the topic the glacial landscape and then carried out practical exercises in groups of four with one teaching assistant for each of four activities. During the exercises, some of the students in the groups were enthusiastic and active, but some were also passive.

The assessment of the learning outcome showed that the average percentage of correct answers did not differ between the two groups (75% versus 77% correct answers, Table 12.1). Answers to question 9 on the definition of the onset of the Holocene were more correct in group 2, due to the content of the question, being better explained in the lecture. To my surprise, there were some incorrect answers to questions that I assumed would be 100% correct. An oral exam or an essay type written exam would be better suited to test how well students perform according to assessment criteria (these had not yet been formulated). This type of formative assessment can guide the need for e.g. prioritizing important learning objectives.

Fig. 12.2. NG1 students working exploring water movement in soils on campus using a sponge as a model. Photo Pia Lund-Nielsen.

Fig. 12.3. Soil pH measurements and using field kits - which soil samples belong where ? Photo Pia Lund-Nielsen.

Table 12.1. NG1 survey of practical exercises before or after lecture

Percent correct answers	**Group 1 Audiovisual before practical exercise**	**Group 2 Practical exercise before audiovisual lecture**
Started surveys, N	21	20
Completed surveys	18	19
Q1	100 %	95 %
Q2	72 %	100 %
Q3	100 %	100 %
Q4	78 %	67 %
Q5	72 %	72 %
Q6	100 %	83 %
Q7	89 %	72 %
Q8	39 %	44 %
Q9 Holocæns begyndelse defineres som Overgangen fra Yngre Dryas til Præborealtiden	29 %	61 %
Average (t-test, H0: same avg., P=0.89^{NS})	**75%**	**77%**

Discussion

The teacher survey confirmed my speculation that keeping ILO's constant, while reducing resources vastly, have caused problems in the teaching system. Cancelling resource demanding practical exercises and field excursions may cause loss of alignment, e.g. loss of competencies. The results of the active learning efforts in the practical exercises will appear after the exam in January 2015 (EESREE), and by observing how well the landscape architect students perform in the following NG2 course in spring 2015.

The pilot study for EESREE, the teacher survey and the main intervention for NG1 showed that practical exercises and field excursions can be incorporated effectively in short modules giving more variation in long course days. Students and teachers agree on their importance of practical exercises and field work (received 35 % of the teachers' votes and 50% of the students' votes).

Using guided inquiry as a student activation activity takes time and requires an experienced teacher who knows when to intervene with validating knowledge. There was a tendency that the exercises due to the short time allocated to them (15 minutes to each of four exercises) could develop into a mini-lecture by the teaching assistants. Patience and time is required, letting the students explore the 'game' and develop their own theories.

The question whether active learning should take place before or after lecturing (e.g. Westermann & Rummel (2012)) is not the key issue here. It was a practical circumstance, allowing for active learning with groups and smaller size classes.

Course descriptions should include knowledge, skills and competencies described in detail along with assessment criteria, and the type of teaching activities should also be spelled out with some detail. Only then, the students can use the course description for guiding their study activities and setting their level of ambition. It is obvious that teamwork among teachers is needed in cross disciplinary courses. Whether this happens seems to be the responsibility of the course leader. There is a risk, that cross-disciplinary multi-teacher courses become serial mono-disciplinary courses. Team based teaching is an emerging challenge to be followed up.

Based on the experiments with teaching formats here, I suggested new assessment criteria to the new course description in November 2014 for NG1. The course has a written exam with all aids allowed (40% weight) for the geology and soil science part. The criteria are:

- "describe landscapes and landscape formation based on geological and geomorphological processes with relevance for Danish conditions"
- "evaluate soils and their suitability for tree growth"

The learning activities in the practical exercises were directly designed to train these criteria, and a better alignment between learning objectives, teaching activities and the final assessment should hopefully result. In order to examine the effect of practical exercises on the EESREE course, a dialogue with the teachers responsible for the final assessment is needed. Positive student evaluations may not reflect their actual realized learning outcome as seen in the EESREE survey.

Conclusion

From the students' perspective, my pilot study on the EESREE students showed that students want more field excursions and practical activities. A full day of lectures and theoretical exercises may cause an information overload, while some hands-on activities in-between can give other, supporting stimulation in the learning process and make the teaching research-oriented, especially if the guided inquiry approach is involved.

The intervention in the NG1 teaching with landscape architecture bachelor students turned out to show that the order of the two – theory first and exercises after or vice versa did not affect the test results. Both groups performed well in answering the test questions. I therefore conclude that audio-recorded lectures can be the activity that in fact allows for inclusion of intensive and direct interaction with only 20-30 students in small groups performing practical exercises as a supporting, active learning activity. This activity allows for developing the guided inquiry approach further.

The block structure with short term intensive courses requires new teaching plans involving diverse teaching and learning activities – continuing the old format and preserving only the lectures and theoretical exercises may cause overload of subject matter. It has proven difficult to find suitable textbooks. Teachers and students agree on the need for diverse activities including field excursions and practical exercises. This study suggests that hands-on activities are valuable and can be fitted into the current week schedule. Future improvements in assessment criteria and final assessment formats in the EESREE and NG1 courses (e.g. an oral exam based on a project report) will show, whether the individual student performance actually improves as a consequence of more activating, practical teaching and learning activities.

A Appendices

Appendices can be downloaded as one file at http://www.dansoil.dk/Filer/A1_to_A7_merged_document.pdf

A1: EESREE survey of student reflections on TLA's in one-week module on soil science in a 15 ECTS course. Page 1 - 10 in pdf.
A2: Teacher survey of choosing course literature and TLA's - results. Page 10 - 20 in pdf.
A3: NG1 survey - assessment of terminology and processes in the glacial landscape by 1) audiovisual lecture followed by practical exercise, or 2) practical exercise followed by audiovisual lecture. Page 21 - 40 in pdf.
A4: EESREE course description(http://kurser.ku.dk/course/nigk13008u/2014-2015) 5070-B1-2E14; Ecology and Ecosystems Science in relation to Environmental Economics. Page 41 - 42 in pdf.
A5: NG1 course description (http://kurser.ku.dk/course/nigb13001u/2014-2015). Page 42 - 43 in pdf.
A6: Practical soil science exercises for EESREE. Page 44 - 47 in pdf.
A7: Practical landscape formation exercises for NG1. Page 48 - 51 in pdf.

All contributions to this volume can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/2015-8/

The bibliography can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/kapitler/2015_vol8_nr1-2_bibliography.pdf/