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Problem Based Learning and the university field course in zoology: the way to success

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Introduction

"Terrestrial Zoology" is a mandatory field course within the "Feltbiologi II" block offered for the first year biology students at the University of Copenhagen. Two years of experience with this course revealed a number of didactic problems negatively affecting educational quality of the course. As a result of the inventory and analysis of those difficulties, a new format of the course is proposed, that is largely based on the principles of the Problem Based learning and Constructive Alignment. Unlike previous format of the course, now the entire group of participating students will be conducting a common zoological study of four habitats, each individual student team being responsible for one habitat. It is argued, that the new format should perform better due to optimal alignment of teaching activities that stimulate broader overall engagement of students.

Late in 2008 the Department of Entomology of the Zoological Museum (ZMUC-ento) at the University of Copenhagen (KU) was asked to run the mandatory field course "Terrestrial Zoology". After two seasons of the field course (summers 2009 and 2010), however, it became clear, that *the design and maintenance of this course at the highest possible pedagogical standard is a very significant challenge*. This article analyzes, why this seemingly basic course is such a challenge. It suggests a new format (program) of the course, largely based on the principles of the Problem Based Learning and Constructive Alignment (in the sense of Barrows; 1986; Biggs; 2003; Biggs & Tang; 2007; Boud & Feletti; 1997; Brooks & Brooks; 1993; Schmidt; 1983).

Course description

Goal

A general purpose of this field course is to expose the biology students of KU to the fascinating diversity of terrestrial animal life exemplified by Danish habitats[1]. After completing the course students should be able to:

1. apply principles of the phylogenetic classification of terrestrial animals;
2. distinguish main groups (types, classes, predominant orders and families) of terrestrial animals;
3. compare habitats and other aspects of biology and ecology of some target terrestrial animals.

Unlike the "classroom course", students are expected to learn through their own field experience as much as possible, primarily by observing, collecting and identifying target animals during field excursions and subsequent laboratory-based work at the field station (Fig. 12.1.c. and 12.1.d).

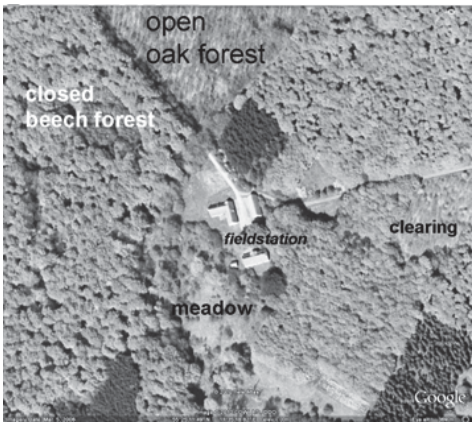
Examination

Student's performance at the course is evaluated by means of the multiple choice questionnaire given to each student. The questionnaire includes 20 questions with 1 right answer out of 4 possible.

Location and practicalities

"Terrestrial Zoology" is held at "Kristiansminde", the field station surrounded by a variety of habitats (Fig. 12.1.a). Each course lasting 3 days is run by 3 instructors. Altogether there are ca. 150-170 students per year. So, they are divided into 8 groups. Usually, each group of instructors teach two courses (two groups of students) in a row (1 full week of work), educating ca. 40 students altogether.

[1] See also: http://sis.ku.dk/kurser/viskursus.aspx?knr=110820&languageid=1



a: Kristiansminde fieldstation and surrounding habitats

b: Mini-lecture by the course instructor

c: Collecting and observing animals by students in the field

d: Work in the laboratory: students are divided into teams, each team working together

Fig. 12.1. Field station, teaching, and student work

Initial format for the course: experience of the first two years

Although the format of "Terrestrial Zoology" somewhat varied from one to another team of instructors, collecting specimens in nature (Fig. 12.1.c) and their study (mostly identification) in the laboratory (Fig. 12.1.d) always stayed as a main activity. Mini-lectures given by instructors in nature (Fig. 12.1.b) or in the laboratory; course Compendium; course library and syn-

optic collection; as well as the Internet were the additional media, where students were getting information supplementary to their practical work. Normally a working day of the course started at 9 am (soon after breakfast), and lasted through the evening even after dinner. All instructors supervised all students: there was no formal assignment of a particular instructor to particular group(s) of students, or other *formal and strict* division of teaching load among instructors. The field course was generally run as follows.

Day 0, evening arrival of the students, informal gathering.

Day 1 in the morning, after the introductory lecture about the course goals, methods and target animal groups, students were led to the excursion in the meadow and forest near the station. There they were collecting their first sample of animals and listening to the improvised mini-lectures given by instructors about the biology of the animals found. After lunch, the rest of the day was spent in the laboratory identifying animals. During this day, the entire group of students was divided into four teams, each team working together at the same workstation (Fig. 12.1.d).

Day 2 Each team of students was assigned with the mini-project (examples of miniprojects: “Fauna of forest floor”; “Fauna of meadow”; “Feeding strategies”; “Coloration”; “Beetles”; “Spiders”, etc.); students were collecting and identifying animals, gathering additional information for their mini-projects, and preparing project-related presentations.

Day 3 Delivery of the mini-project presentations by teams of students (10 min of talk, plus 5-10 min discussion for each team); examination; evaluation of the course; clean-up and departure.

Problems of the initial format of the course, and their source

The outlined initial format worked well overall, the course was mostly getting high evaluations by the students. However, we encountered a number of problems that negatively affected the efficiency of the course. *These problems were: varied degree of engagement of the students into the course activities; low motivation of some of them; varied degree of student’s performance at the mini-projects presentations day and multiple-choice exam that included low level of learning demonstrated by some of them;* ***very*** *high workload for instructors that made leading two courses in a row a*

physically and emotionally very demanding experience. The main causes of these problems belong to two categories: *objective* and *subjective*. Objective causes are those that come from the conditions and qualities of the course itself. Subjective causes come from the teaching methods applied in certain conditions. Objective causes cannot be changed, but their challengers can be better met by *improved pedagogical techniques*. As regards subjective causes, *these improved techniques* can hopefully completely eliminate them.

Objective causes (1-5):

1. *Very broad topic and very little time*. Within the constraints of 3 days students must get basic but well-structured knowledge about several animal classes, dozens of animal orders; learn their position in the classification, main distinguishing characters and common representatives; some data about their biology and ecology. Students must learn how to collect and preserve animals and how to use identification keys. All this is simply too much for a limited time period! *To succeed, an acceptable level of simplification and generalization of the entire pool of data must be found and all teaching materials (compendium, lectures, reference collection, etc.) must be tuned and aligned to the level of perfection.* We could not achieve that perfect equilibrium within the used format yet.
2. *Need to explain complex concepts even for seemingly easy tasks*. In order to get basic but firm knowledge about terrestrial animals, students must comprehend several rather complex concepts. For example, using zoological classification requires some understanding of the principles of phylogenetic systematics and biological nomenclature that are rather abstract and frequently misunderstood even by professionals. Use of the identification keys assumes familiarity with the respective animal morphology that, for insects alone, is a very complex, structure- and terminology-rich subject. The most efficient way of presentation of these concepts at the appropriate level was not found.
3. *Most of students have background remote from field biology*. Based on 2 years of experience with the field course, I can firmly state, that students are interested in nature, and they want to learn. With very rare exceptions they had fun having this course. But, also with very rare exceptions, their level of preparation for the field of organismal biology is very low: it is hard to believe, but most of them, at the beginning of the

course, could not distinguish an oak from a beach, and a beetle from an earwig, and similar so common types of organisms! It is a challenge of this field course to get modern city-dwelling students closer to nature.

4. *Uneven academic level of the students*. When students were divided into teams for their mini-projects, it was unavoidable that they grouped themselves so, that teams greatly varied in academic strength, motivation and work discipline. These teams performed differently throughout the course, and quality of their resulting mini-projects, collections and exam results varied significantly. Strong teams were stronger in everything, whereas weak, less motivated teams were respectively weaker in everything. The initial format of the course did not stimulate weaker teams to perform better and catch up with stronger students. Also, it did not particularly stimulate instructors to work more with the weaker teams in order to level up an *overall* performance of all students in the group.
5. *Too many variables affecting the course*. Nature itself makes the course a challenge. Extended rain, drop of temperature, cold nights, and other common features of Danish summer may decrease the amount of insects and other invertebrates easily available for 4 collecting during short excursions, and thus cause a problem for a course that lasts 3 days only.

Subjective causes (6-10)

6. *Lack of a single goal (unifying idea) amalgamating all practical activities of the course*. The initial format of the course was strongly tied to the classical, morphology-based systematics and identification of animals. Mini-projects added some general biological content to the agenda of the course, but they were only peripherally tied to the identification process. No matter how we, instructors, love our subject of systematic zoology, the reality is, that unlike 60-40 years ago, systematics is no longer a clear-cut realm of biology and biological education. It is deeply amalgamated within the evolutionary biology, a synthetic subject that arose during the last half-century. It is only *a minority of students who have genuine and deep interest to the systematics-related knowledge* and systematic activities *per se. The majority of students find systematic zoology itself too special and too difficult subject to learn*. They are not committed to invest an effort into learning systematics, when they are unable to comprehend its broader biological

applications. So, it is necessary to find a holistic aspect for the course, some general idea that does involve systematics, but, at the same time, is interesting for the *majority of students*, not only for the elite.

7. *Loosely defined course agenda*. Shortage of time and the outlined complexity of the subject taught make structuring the course very difficult, *especially of the introductory first day*. The information-rich introductory lecture delivered that day was hard to digest, and it was only indirectly connected with the field activities immediately to follow. Lack of a clearly defined goal of all field and laboratory activities did not affect self motivated and interested students. However less motivated students, not being guided by a clear working protocol, took passive approach from the beginning, and thus had smaller chance to get interested later, by doing something and finding that to be engaging. Lack of the clear working protocol for the course could be argued as an advantage, giving the course some flexibility. The problem is that such flexibility seems to be an advantage of a longer course, whereas our short course does not provide enough time for that.
8. *Poor alignment of course elements*. Although it is was expected that the DAY 1 was a "warm up" before the mini-project, alignment between the DAY 1 and DAY 2 was loose. Also constructive alignment (in the sense of Biggs (2003); Biggs & Tang (2007)) among the introductory lectures, mini-lectures in nature, mini-projects and students practical work was not straightforward sometimes. Therefore, the so short and precious time available for the course, was not used with the maximal efficiency.
9. *Complex identification keys*. All students of the course had difficulties when they used identification keys in the course Compendium. It is extremely hard to make a key workable and easy at the same time, since even just around the field station the terrestrial fauna of invertebrates is amazingly species-rich. Simplicity of the key comes at a cost of the omission of numerous taxa, that, in turn, makes a key useless. However, the keys can be gradually tuned to the most common local taxa. Making the key as pictorial as possible, and supplementing the key by a synoptic collection, seems to be the way for improvement.
10. *Lack of some teaching equipment*. Although the course overall does not require complex equipment, we were missing two devices. One is a camera connected to the dissecting microscope and a computer/projector allowing to demonstrate a process of the morphological study and dissection of a small animal on a classroom screen to an entire group

of students. Another needed piece of educational equipment was a paired dissecting scope that would allow simultaneous observation of the same object by two people. A couple 5 of such paired scopes would allow us to demonstrate many students various morphological structures relevant for identification on a very efficient individual basis.

New structure of the course: general description

Unlike the earlier structure, the entire group of students (ca. 20 students) has a clear-cut common goal to achieve during 3 days of the course, *that is a comparative faunistic and ecological study of the terrestrial fauna of the four habitats near the field station*: 1) closed beech forest, 2) open oak forest, 3) meadow and 4) forest clearing (Fig. 12.1). For that purpose the entire group is divided in four teams (4-5 students per team), each team working with one habitat. All teams collect animals in their respective habitats by means of the shared standardized collecting protocol consisting of: a) Malaise trap, b) 10 pitfall traps, c) sifting ground-based debris (400-500 g of sifted material to be processed with the Berlese funnel), d) opportunistic, time-calibrated hand collecting in different microhabitats (for example 0.5-1 hour of collecting). Each team sorts the collected samples into morphospecies and identifies them at least to the level of order. Identified material is recorded by each team in a *standardized Excel arc* that accounts numbers of morphospecies per each animal order, and numbers of morphospecies from different orders collected by various methods. Based on that Excel arc, each team produces a basic statistic analysis that describes the fauna of their respective habitat. That statistics must show, for example, which animal orders are particularly species rich and species poor in a given habitat, how are species distributed by microhabitats, which animal groups are better sampled by certain collecting method, etc. Each team delivers their filled Excel spreadsheets to the instructor (for the upcoming summary for all habitats), and uses that statistics in their resulting presentation about the fauna of the investigated habitat. Each team delivers a synoptic collection of morphospecies they have collected and identified to various extent, and a simple eco-faunistic presentation outlining the fauna of the respective habitat (largely based on the collected specimens, but also with reference to literature and internet-based data for some general points). Although students are given some degree of freedom regarding the content and format of the presentation, the structure of the presentations is pre-defined so that reports

about different habitats are compatible for comparison. At the same time, Excel spreadsheets with the filled data from each team (delivered directly to the instructor, at least 2 hours before the "wrap up" session) are used for the summary presentation that compares all explored habitats delivered by instructors after team's presentations. Student presentations, associated questions and discussion, and a summarizing presentation by instructors are held in the classroom as the final wrap-up session followed by the exam and course evaluation.

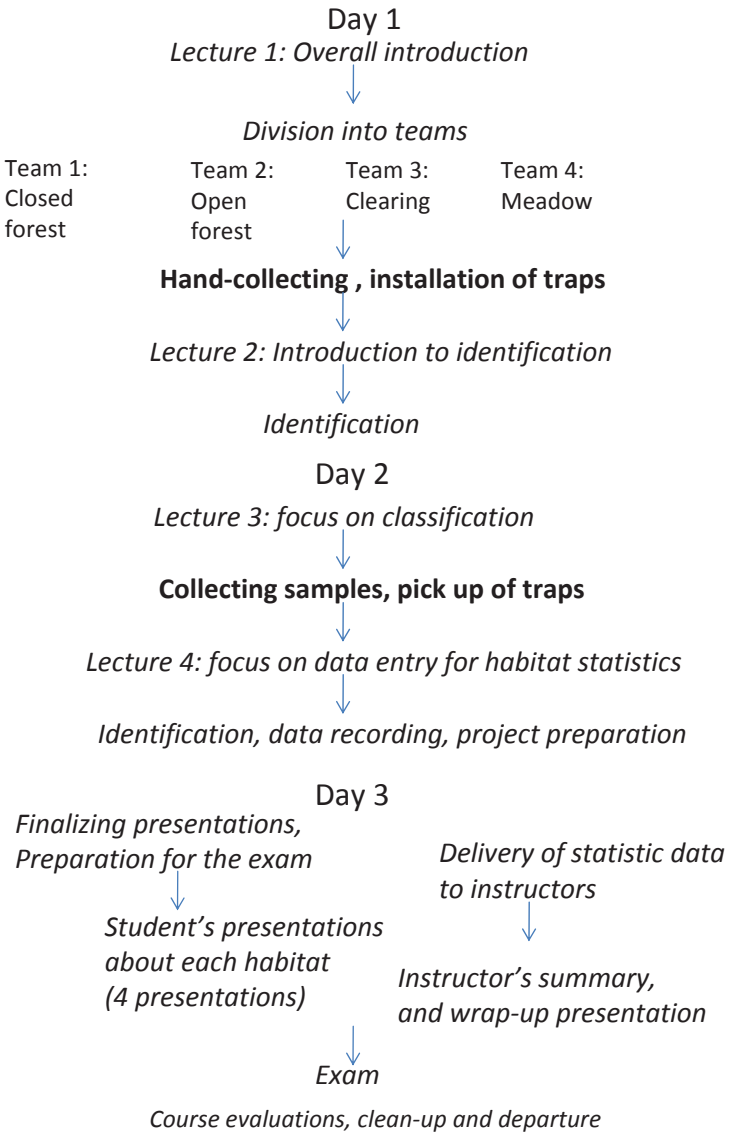


Fig. 12.2. New format of the field course: scheme

Unlike the old structure of the course, each team will be mainly supervised by a particular instructor from the introductory to the final part of the course.

Daily schedule according to new structure

Day 0, evening arrival of the students; informal get-together and introduction of the course. Division into teams.

Day 1 Before lunch introductory lecture 1, division into teams, demonstration of the habitats and collecting techniques, trap installations, hand collecting; after lunch: introductory lecture 2, sorting, mounting and identification of the material in the laboratory.

Day 2 Before lunch: lecture 3 and detailed introduction of the Excel spreadsheet for data recording. Collecting material from traps, and hand collecting; after lunch: lecture 4; continued identification, data recording and data processing in the laboratory.

Day 3 Before 6 lunch: delivery of the summary statistics to the instructors, preparation of the presentations; after lunch: delivery of the presentations by teams, summary presentation by instructors; short discussion; exam (multiple choice) and evaluation of the course; clean-up and departure.

Discussion: how the new format of the course targets the outlined problems

Focusing the whole course on a comparative faunistic-ecological study of several habitats, we maintain collecting and identification as main practical activities of the students, leaving the goal of learning terrestrial animal diversity intact. But we also add a needed unifying goal and central idea to all activities of the course and thus meet the reality that many more students these days are interested in evolutionary ecology than in pure zoology or systematics. The new ecological aspect of the course, that includes *identification of animal as a tool towards bigger goal,* may lure students towards systematic zoology.

Having a research-like goal of the course, we place students in the position of nature explorers giving them freedom of search, what should increase their interest and motivation. At the same time, constraining their

work with a certain standard for data recording built in within the designed Excel arc (data recording form), we supply students with a straightforward protocol for their "research", actually channeling their practical activities. That protocol should also improve time management, preventing students from spending excessive time on particular task (e.g., specimen preparation or identification) and thus helping them to achieve all goals of the course within the very limited available time. That protocol should be particularly helpful for less motivated or less skilled students, who usually perform better if more guidance is provided.

Setting the entire course as a collective research project where each team contributes a piece of data for a common goal (summary comparison of habitats done by instructors), and where instructors are also involved as participants, not only supervisors, raises a level of responsibility for each team. Weaker teams will try to reach the level of performance demonstrated by stronger teams. From the side of instructors, the need of getting compatible results from all teams for the summary presentation will stimulate us to invest more time into more individual work with under-performing teams. Desired paired dissecting scopes would be particularly necessary for exactly this type of work. Common goal for all teams should make each student feeling as part of one big research team throughout the course, such increase of a "team spirit" being always a good thing in the field.

Having a clear and practical goal of the course will help to align all course activities around that, especially lectures given by instructors. Each given lecture will be connected to the previous and to subsequent ones using a progressive sequence of teaching-learning alignment, all of them eventually leading towards making the students able to fill their spreadsheet with the data. Such connection will allow repetitive approach to the most complicated concepts (Fig. 12.3) that are usually difficult to digest in one shot. These are lectures introducing practical aspects of animal morphology and identification that will greatly benefit from applying the projection of the dissection process from under the microscope to the screen. Having the mentioned final goal of comparable taxa lists will also set standard for the keys. Need for a decent list of determined taxa by all teams (not only the best) makes an existence of pictorial key a must.

A standard collecting protocol required by the proposed new structure of the course, that includes a variety trapping techniques used by all teams, will increase the amount of sampled species collected by students. Also, unlike hand collecting, traps always bring some catch, even in the suboptimal weather conditions.

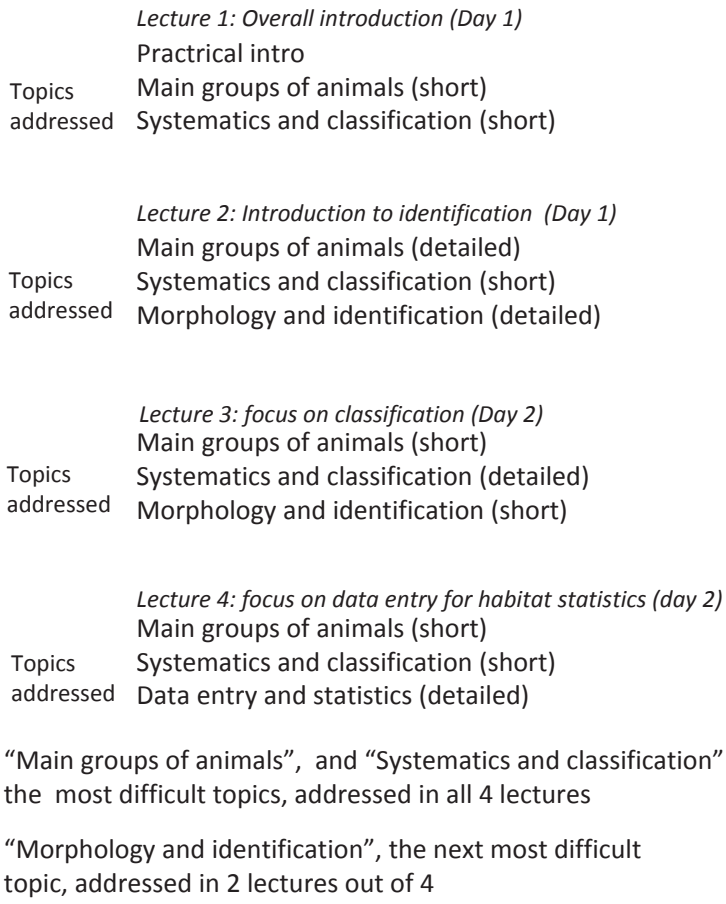


Fig. 12.3. Lectures of the course in the progressive sequence of Teaching-Learning Alignment.

Finally, assignment of an instructor permanently supervising 1-2 teams throughout the course (in the field and laboratory) will increase the room for informal communication of students and instructors, allowing instructors to better see individual abilities of the students and their needs. At the same time, the workload of individual instructor will decrease, leaving energy for equally high engagement throughout the entire week or two of teaching. That structure does not mean that instructors will be restricted to their teams only. Each of them must still operate for an entire group. But, instruction becomes more organized and more channeled.

Acknowledgements

It was great to see during two years, how the "Terrestrial Zoology" course ignites interest to the field biology among students. They are greatly acknowledged for that, especially such rare zoological species as disorganized and non-motivated students. They were really the ones who stimulated changes in our pedagogical techniques. I also thank Henrik Enghoff, Steen Dupont, Thomas Pape and Rasmus Aagaard Jensen, my co-instructors of the course in years 2009 and 2010, respectively, for numerous helpful discussions and small "experiments on humans" we made trying to improve our teaching of the course. Camilla Østerberg Rump and Lars Ulriksen are sincerely acknowledged for critical reading of this project and helpful suggestions that led to its improvement.

All contributions to this volume can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/2009-2-1/

The bibliography can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/kapitler/2009_vol2_nr1_bibliography.pdf/