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Utilizing case-work for inducing reflective thinking and interpretation skills

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Introduction

A multi-disciplinary approach in university teaching involves teachers and/or scientists with different scientific expertise as well as didactic competences. However, the multiple teacher courses can result in teachers only having the opportunity to teach one or two times during a course. The students may therefore be exposed to many different forms of teaching during a course. It can therefore be an advantage to present in every lecture the intended learning outcomes (ILO's) so the students know what is expected of them in terms of gained knowledge and/or expertise from each lecture. In general, lectures are used to present the scientific information whereas several different teaching learning activities (TLA's) is needed for obtaining deep learning enabling more reflective thinking and interpretation skills.

Generally the use of lectures in the means of student learning can be questionable. Several statements from the paper by Gibbs (1981) are illustrating the possible drawbacks of lecturing:

- Lectures is not more efficient than other methods in relation to the ability of students to learn factual material – it is even suggested that unsupervised reading is more effective in terms of learning facts.
- Students are inactive during lectures – more than 75% of the students are having passive thoughts about the subject or other irrelevant issues.
- Lectures are not motivating.

- Student notes from lectures only contain 21% of the presented material and in some studies less than 15% of students taking notes did subsequently read the notes.
- The lecturer cannot easily adjust to individual students existing knowledge and manner of learning – lectures are generally not very flexible.
- The final ILO's for individual students varies in relation their knowledge/course prerequisites.
- The lecturing pace is very critical as students are forced to understand what is being said or just attempting to record what is being said. Is it facts-based lecturing or more complex information being presented?

However, the potential drawbacks of lecturing are depended of the stated ILO's for the course or the individual lecture and how the lecture is combined with other TLA's during the whole teaching session. The objective of a given lecture can be different from the overall course objectives if the lecture is a preparation for student activation in other TLA´s resulting in achieving the course objectives (Gibbs 1981), e.g. more deep and complex understanding of the topic. However, activation of students during the lecture is very important, as studies have shown that a low activity level results in decreased learning. In a traditional lecture with the lecturer having more or less a monolog in the classroom the student activity level is low and a significant part of the teaching information is not absorbed by the students. It is estimated that an average student is able maintain focus for approximately 10-15 minutes, then the concentration drops markedly. However, maintaining the high concentration level can be achieved by introducing varying TLA's forcing the student to change and interact in the teaching session (Biggs & Tang 2011), see figure 15.1 for overall student learning outcomes in relation to activity changes.

Throughout the first one or two years at the university the students are often not exposed to any significant activation during lectures, especially in the basic courses in chemistry and mathematics with > 100 students in the auditorium. In following courses it can therefore for some students be quite challenging or even embarrassing to ask questions and interact in the teaching in front of the other students, either because the student feels scientific or personally insecure. To say something wrong or "stupid" will for some students be the same as a personal defeat and a very awkward experience. It should always be ok to ask questions no matter quality or how scientific the question is. The teacher should acknowledge the question and used it constructively. A course with many teachers will potentially also have the

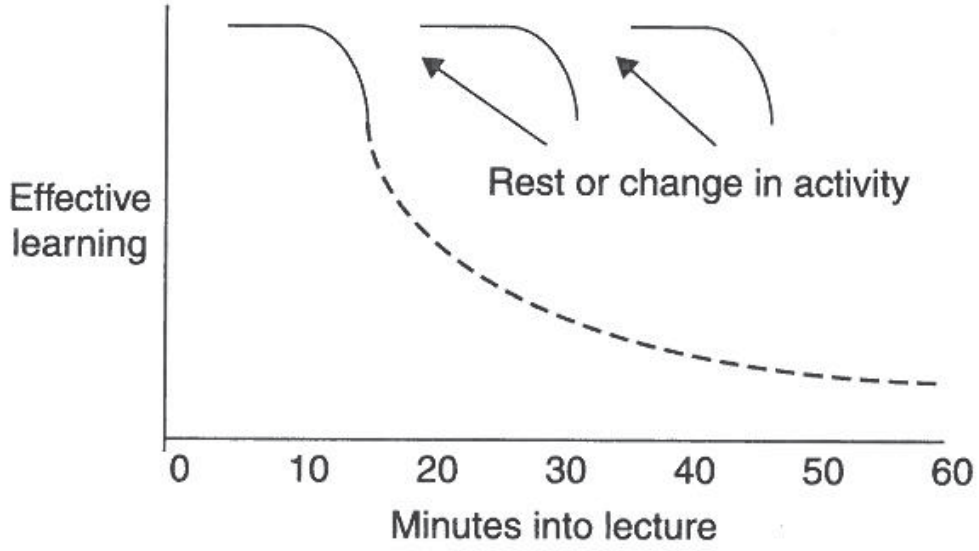

Fig. 15.1. The effect of no activity versus several activities on student learning during a lecture (Biggs & Tang 2011).

side-affect that students do not feel "safe" by the individual teacher and in such cases it is very important that the teachers do an extra effort to create a safe and open atmosphere facilitating the teacher-student interface. Furthermore, improving how students prepare before a lecture, e.g. reading the text-material at home, will also increase their scientific confidence. As a university teacher I have great passion for passing on knowledge and increase motivation for further studying outside the classroom and laboratories. It is especially rewording teaching at courses where the students are so eager to learn and so inquisitive that the teaching transforms into an explorative dialogue, resulting in a more reflective and deep learning. So the question remains how to facilitate this process in relation to varying scientific areas and student prerequisites. I find interactive and dialogic teaching very attractive and I am using this approach by facilitating students to combine and analyze presented facts-information and obtained laboratory results in exercises following the lecture or conducted experiments, respectively. In the present project I examined the use of case-work in relation to gain more reflective thinking and increased interpretation skills. The MSc course Advanced Plant Ecophysiology was used as a template as the course has been modified significantly throughout the last two years in order to increase the deep learning.

Course context

The course Advanced Plant Ecophysiology give students an understanding on how plants function in diverse environments and their physiological responses to environmental and climate change[1]. Eight teachers are involved in this course teaching on their particular favorite topic in according to the course description and ILO's. I have been involved in this course during the last five years presenting various topics within my expertise. However, during the last two years the course has been modified quite a bit. Previously the course was named Plant Ecophysiology and was a joint BSc and MSc course. The previous student evaluations were mixed especially in relation to teaching material, and the organization and structure of the course. In addition, the course attracted per tradition students from very different backgrounds (biology, geography, biotechnology, agronomy) resulting in students having very diverse course prerequisites. This resulted necessarily in lectures and teaching sessions presenting basic knowledge before actually handling the intended individual ILO's for the course. A new course responsible gave the opportunity to change and modify the course. A new text book was chosen and the overall course structure was aligned with the textbook used. The first year with the new text book and a new portfolio of teachers involved having other ideas regarding didactic approaches resulted in very positive student evaluations. However, in the first year with the changes the majority of the teaching was focused on presenting the fundamental scientific facts, ensuring the students were able to explain and describe the fundamental facts described in the ILO's in the course description, unconsciously resulting in learning at a relatively low SOLO level (The SOLO taxomony; Structure of Observed Learning Outcomes, Biggs & Tang (2011)). In addition, the applied TLA's were often solved by finding the answer directly in the text book with no re-thinking or reflection. The assessment consisted of four multiple choice exams ensuring the student to be focused during the course, but unfortunately also resulting maintaining a low SOLO level. It was therefore decided to change the course ILO's with increasing complexity and to introduce TLA's in the teaching sessions facilitating more reflective thinking and interpretation skills. Furthermore, it was also decided to change the course to a MSc course with the idea that this will ensure a higher basic understanding of the biological and soil processes describing plant ecophysiological processes enabling to focus more

[1] Faculty of Sciences (2013). Kursusbeskrivelse Advanced Plant Ecophysiology 2013, URL: http://www.courseinfo.life.ku.dk/Kurser/LPLK10382.aspx

on detailed and complex scientific issues in according to the changed ILO's in the course description. The assessment structure was also changed, as two multiple choice exams were exchanged with an 2½ hour written exam with small assay questions evaluating students ability to combine and reflect upon their obtained knowledge.

Teaching and learning activities – special focus on "deep learning" cases

In the 2013-course, I was responsible for half a day of teaching in two subtopics; i) Acquisition of micronutrients and micronutrient efficiency and ii) Tolerance to acid and calcareous soils. I constructed five ILO's with verbs from the SOLO taxonomy which were presented at the end of the lecture. There are several levels of understanding illustrating the learning outcomes in relation to their complexity. The five ILO's for my lecture were:

- *Understanding* of strategy I and II mechanisms *enabling you to design* nutrient efficient intercropping productions.
- *Obtain insight* into micronutrient interaction as well as physiological and molecular mechanisms involved in micronutrient efficiency *enabling you to design* micronutrient efficient genotypes.
- *Achieve detailed knowledge* regarding the consequences of soil acidification on soil fertility as well as the physiological and biochemical consequences of aluminium toxicity.
- *Acquire complete understanding* of the mechanisms involved in aluminium tolerance for different plant species *enabling you to design* aluminium tolerant plant genotypes.
- *Be familiar* with the characteristics of calcicole species.

I used verbs from the unistructural phase (*be familiar, obtain insight, achieve information, acquire understanding*) which were combined with verbs from the extended abstract level in the qualitative phase (*design*). Initially I did not show the ILO's directly but presented them as modified check points to illustrate the sub-topics for the lecture and let them re-think and combine knowledge using their own terms and capacities based on the initial lecture and home-reading of text-book instead of utilizing the leading-statements listed in the ILO's. As the majority of the students came from Department of Biology, I was not familiar with the knowledge prerequisites of the students. The intention was then to have an initial part of the lecture presenting some fundamental facts essential for understanding

and reflecting on the more complex research topics. I therefore started the lecture with some basic definitions and questions to get a feeling regarding their scientific level. During the lecture, there was room for clarifying questions and I also made small questions for checking whether the students still were focused on the present lecture, e.g. a 3 minute sum-exercise regarding reflective thoughts on pros and cons of the Fe-deficiency induced mechanism just been presented. Right from the beginning of the lecture, I tried to make an informal atmosphere and stating that all questions and comments were welcome and that it is joint effort in terms of having an efficient learning session. After each introduction of the individual sub-topics, I have made several case-based exercises in which it was the intention that students should utilize the gained information to combine and reach an increased level of understanding within the two tub-topics. I have listed one example from each sub-topic, respectively (see Figure 15.2 and 15.3).

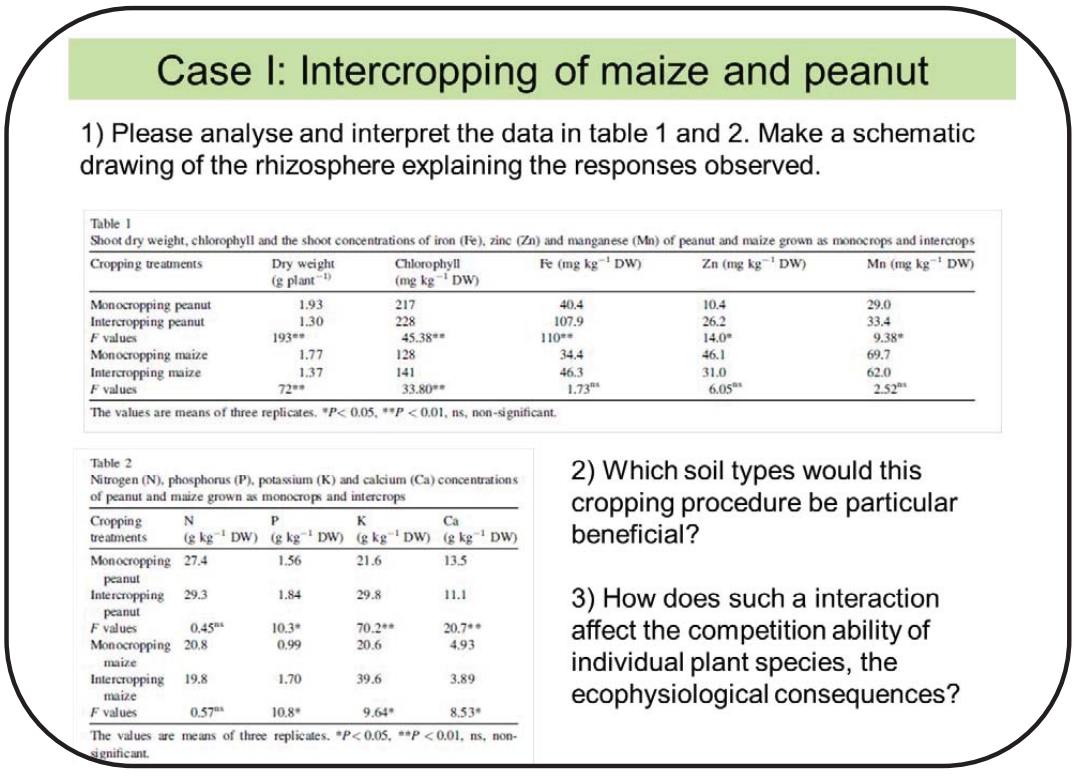

Table 1
Shoot dry weight, chlorophyll and the shoot concentrations of iron (Fe), zinc (Zn) and manganese (Mn) of peanut and maize grown as monocrops and intercrops

Cropping treatments	Dry weight (g plant^{-1})	Chlorophyll (mg kg^{-1} DW)	Fe (mg kg^{-1} DW)	Zn (mg kg^{-1} DW)	Mn (mg kg^{-1} DW)
Monocropping peanut	1.93	217	40.4	10.4	29.0
Intercropping peanut	1.30	228	107.9	26.2	33.4
F values	193**	45.38**	110**	14.0*	9.38*
Monocropping maize	1.77	128	34.4	46.1	69.7
Intercropping maize	1.37	141	46.3	31.0	62.0
F values	72**	33.80**	1.73^{ns}	6.05^{ns}	2.52^{ns}

The values are means of three replicates. *P< 0.05, **P < 0.01, ns, non-significant.

Table 2
Nitrogen (N), phosphorus (P), potassium (K) and calcium (Ca) concentrations of peanut and maize grown as monocrops and intercrops

Cropping treatments	N (g kg^{-1} DW)	P (g kg^{-1} DW)	K (g kg^{-1} DW)	Ca (g kg^{-1} DW)
Monocropping peanut	27.4	1.56	21.6	13.5
Intercropping peanut	29.3	1.84	29.8	11.1
F values	0.45^{ns}	10.3*	70.2**	20.7**
Monocropping maize	20.8	0.99	20.6	4.93
Intercropping maize	19.8	1.70	39.6	3.89
F values	0.57^{ns}	10.8*	9.64*	8.53*

The values are means of three replicates. *P< 0.05, **P < 0.01, ns, non-significant.

Fig. 15.2. Exercise case-example for the sub-topic "Acquisition of micronutrients and micronutrient efficiency".

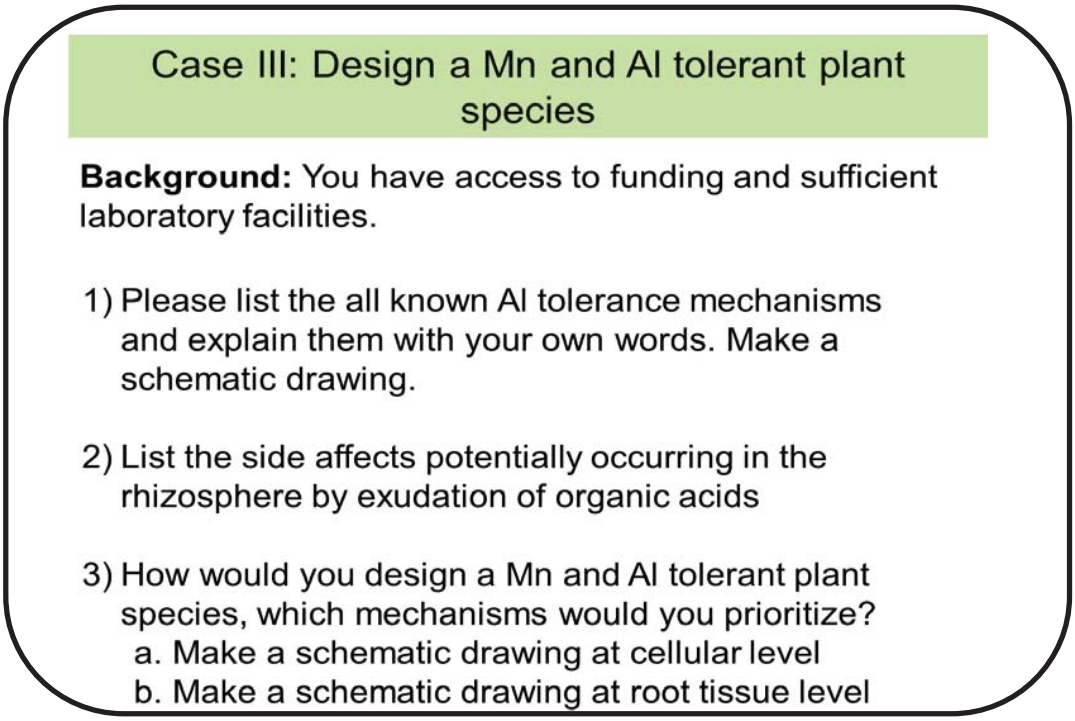

Fig. 15.3. Exercise case-example for the sub-topic "Tolerance to acid and calcareous soils".

For both cases the ILO's in this predominately student-active TLA were at the extended abstract level in the qualitative phase, trying to combine and utilize the presented information in for instance interpretation of data or designing hypothetical plant lines with increased tolerance for growing on specific soil types. At the introduction of the cases it was also stated that all answers were accepted as long as the students could argue with scientific arguments. In addition to this, the students were divided in two groups, each having the responsibility of individual cases resulting in the groups being inter-depended on each other's work-efficiency and quality. By doing this the students were very motivated and also forced to add an additional layer of reflection before being able to complete the cases. Finalization of the cases was done by either student presentation of case-responses at the blackboard or by me guiding through the cases with student responses from the class room. In both approaches, all answers and responses were not instantly confirmed or rejected by me, but I tried to involve all students in a dialogic manner until the individual topics/cases were sufficiently treated in relation to the ILO's for the whole teaching session. In this respect it is im-

portant that me as teacher did not interfere with the students (guidance but not answering strait away) so scientific doubt and discussion were allowed until the right answer or reflection appeared.

Evaluation and conclusions

After my day of teaching, all students were asked to fill out an evaluation form consisting of four questions:

- What did you learn that was new?
- Which questions relating to today's session are still left unanswered?
- What was good about the session today?
- Do you have any constructive criticism relating to today's session you would like to provide?

From this type of evaluation sheet, one can expect as many different answers as there are students. However, the relatively simple questions were used to acquire a fast evaluation regarding the lecture but just as important also to gain information regarding specific topics being insufficiently understood enabling the teachers to include a small specific re-cap in the next teaching session.

Unfortunately, only ten students were registered for course and eight were present in my lecture. In the beginning of the lecture it was relatively hard to get the students activated. This was unfortunately related to several major gaps in fundamental knowledge, which normally should be obtained in bachelor courses. This is not an uncommon observation in courses attracting students from other faculties or education programmes. However, I tried to lift their basic knowledge while maintaining the goal listed in the ILO's resulting in a fairly rapid pace in the lecture also being mentioned by a couple of students in the evaluation. After several TLA's in the lecture it seemed as the students were catching the scientific information and able to respond accordingly to my small questions and sum-exercises during the lecture. My use of case-exercises following the lecture was conducted with a high level of student activation, it seemed as all students were active, both during the group work but also during reviewing the case-responses at the end. In general, the case-exercises received very positive evaluations, student citation "the theoretical exercises were very good and served to elucidate some of the things which are very unclear in the book (e.g. strategy I and II iron uptake) – so that was very, very nice." From the discussion and case-responses we had in plenum, I could to a large extent tell that the

students had achieved what I had intended they should learn. They were able to reflect on the obtained information and relate to presented scientific data, they could explain the processes and definitions and put them in context to varying natural conditions as well as being able to go beyond what we had discussed during the more formal part of the teaching. The scientific reflections and thoughts made in the class room were at a higher level than is stated and discussed in the text-book. At the final written assessment I have one question regarding processes involved in soil acidification and the causes of these. The majority of the students were able to extract the right processes followed by detailed explanations for the mechanisms involved. This summative assessment told me that the students had learned what I laid out in my IOL's for this specific sub-topic.

Perspectives

Even though that the students reported in the evaluation schemes that there was a good balance between lecturing and case-exercises, I would for the next course plan extra time for case-work as it was my impression that this type of TLA's was very efficient in obtaining efficient learning at a high SOLO level. This would require a more focused and aligned lecture with less details on sub-sub-topics. Pre-assignments could also be handed out involving the students before the lecture. In future courses it could be exiting to increase the deep learning by allowing more actual teaching time to be used for reflective case-work (theoretical and experimental) at the level of research grant applications so we get the students to contribute to forming a novel research hypothesis. More home-preparation will be needed in this case, for instance besides studying text material and study questions also E-lectures presenting the fundamental facts could be part of home-studying. Then the actual time at the University can be used for difficult exercises and scientific topics and stimulating the deep learning by increasing the scientific level in actual and relevant scientific cases. The challenging dilemma regarding the missing prerequisites of the students is also something which needs additional focus, especially related to the course now being MSc course only. It can be suggested that one session in the beginning of the course should be used to re-cap the most important fundamental knowledge needed for obtaining ILO's in the course description. However, as the course is a multipledisciplinary course this may very well be complicated to do whereas small adjustments in the individual lectures seem more applicable. In this aspect it is important that the overall SOLO level is main-

tained as it is the responsibility of the students to align their prerequisites with the prerequisites stated the course description.

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