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Generation of appropriate learning activities for a student-activating learning

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Introduction

Knowledge is constructed through learner activity and interaction. Activity has two main roles. The fact of being generally active provides general alertness and efficiency. Activity specifically keyed to the intended learning outcomes (ILOs), using different sensory modes of learning to provide multiple access to what has been learned, is a very powerful way of learning.

Much of what is considered good practice in higher education is based on the assumption that active learning is more effective than passive learning and that interaction between the teacher and the student, among students, and between students and course material is a critical part of active learning (Mehlenbacher et al.; 2000). Being active while learning is better than being inactive. Activity heightens physiological arousal in the brain, which makes performance more efficient (Biggs and Tang; 2007).

Wittrock (1997) describes a study, where students were required to learn from text in increasingly active ways: reading silently, underlining important words, writing out the key sentences containing those words, rewriting sentences in one's own words, to the most active, teaching somebody else the material. There was a strong correlation between extent of activity and efficiency of learning (Wittrock; 1997). Similarly Felder (1993, 1995) has emphasized the integration of active and collaborative learning into engineering education for more than a decade and has reported dramatic results in terms of student responsiveness, satisfaction, and problem-solving flexibility with curriculum content.

Interactive teaching is a highly effective mode of activating students (Biggs and Tang; 2007). Becker and Michael (2001) have observed, from their extensive longitudinal survey on teaching methods in undergraduate economics courses, that the preferred method of lecturing among students is "chalk and talk". In the conventional 45-min. lecture, students lose concentration generally after approximately 20 min., and learning is no longer optimal (Newble and Cannon; 1998; Brown and Manogue; 2001). This process can be countered by adding activating elements into the lecture.

Problem-based learning (PBL) is an example of a very efficient approach towards student activation (Biggs and Tang; 2007). In PBL, the starting point for learning should be a problem, query or a puzzle that the learner wishes to solve. PBL is a student-centered instructional strategy, in which students collaboratively solve problems and reflect on their experiences. It was pioneered and used extensively at McMaster University, Hamilton, Ontario, Canada (from Wikipedia). Characteristics of PBL are: learning is driven by challenging, open-ended problems; students work in small collaborative groups; teachers take on the role as "facilitators" of learning. Accordingly, students are encouraged to take responsibility for their group and organize and direct the learning process with support from a tutor or instructor. Advocates of PBL claim it can be used to enhance content knowledge and foster the development of communication, problem-solving, and self-directed learning skill.

Students learn through activating different sense modalities: hearing, touch, sight, speech, smell and taste. The more one modality reinforces another, the more effective the learning (Biggs and Tang; 2007). Lecture theatres offer less scope for activity than for example wilderness areas, but it is possible to keep students relevantly active in the classroom. It is a good idea to break up long periods of lecturing with different activities such as multiple-choice questions, short-answer questions, essay questions, short writing assignments, classroom simulations or experiments, etc. Better still is when the activity addresses specific intended learning outcomes. Providing learning activities relevant to engage the students with the ILOs is thus of great importance.

Objectives

According to many authors cited in the Introduction, learning becomes more effective if the participants are active. In order to achieve improved learning, there have been developed such methods as for example PBL and case studies. They are effective but I do not see them as always applicable. Simpler ways to improve the learning process of university students were therefore of great interest to me. I have introduced different activating elements into my lectures in order to test and evaluate the concept of interactive teaching and examine the usefulness and acceptance of different activating elements among the students. This study was carried out by lectures, which I held at the courses “Molecular Plant Biochemistry and Physiology” and “Bioinformatics 2”.

Methods

03-12-08 I gave 2 lectures (1.5 h in total) at the course Molecular Plant Biochemistry and Physiology (240028). There were 9 students during my lessons, while there should be 12 students on the course. It is an elective course offered at the Department of Plant Biology and Biotechnology, Faculty of Life Sciences. The course is offered for the 1st year master students of the Biology-Biotech program.

06-01-09 I gave 2 lectures and 3 practical exercises (3 h in total) at the course Bioinformatics 2 (240006). There were 10 students during my lessons, while there should be 14 students on the course. It is an elective course offered for “students at the master level working in areas of biology who are interested in applying bioinformatics in combination with other biological sciences as well as students interested in being familiar with the basic concepts and principle applied in bioinformatics”.

My lessons consisted of an introduction and then presented a real-life case that has already been carried out by me during my research. Since the methods and techniques used to solve the case were very new and complicated and the students were not familiar with them, I gave up with designing a PBL-based lesson.

I have prepared a number of TLAs (teaching/learning activities) related to the content being discussed during the lectures. Most TLAs were developed in such a way that they suited the ILOs, which were quite specific to the particular professional area. I have mostly used a simple form for student activation, which is to ask questions to the students during lecture, they had the opportunity to respond. Lectures were interrupted several times, and students were encouraged to take a position on and then answer the questions. The questions were both convergent and divergent (Biggs and Tang;

2007, p. 121). In the case of the convergent questions, "why"-questions was asked afterwards to hear the arguments for the answer. Once I used a graph to the question, where students were asked to interpret the graph in relation to the topic that was reviewed. Most of the questions were individual (asking questions and expecting individual students to answer them), but some were based on a group work (with 2-3 students in group) for 2-5 min. One question was asked in such a way that the students had to answer it with a YES/NO answer by raising hands.

I have used videos and whiteboard in several occasions. One TLA was problem-based: I gave one difficult question (problem) somewhere in the beginning of the 1st lecture, and then I gave the necessary background for this problem to be solved. I came back to the problem at the end of the 2nd lecture. Students had to work in 4 groups assigned by me (2-3 students per group) to solve it. To help the students solve the problem, I pointed at one slide during the presentation, telling them that this information would help them to solve the problem, reminding them the problem in question.

One of the two computer exercises solved by the students in groups during the Bioinformatics 2 course was used for the exam.

To get a quick indication of how the lessons went (students' learning and my teaching) and which points should get more attention next time, I gave a questionnaire to the students with two questions (see all the answers in Appendices A and B):

- What were the most important points of this lecture?
- Did you have any particular difficulties during this lecture?

If some quite minor aspect would be seen as "the main point", this would be an indication that either I or students have a problem. The second question was asked to point out what should be discussed better the next time.

Results and discussion

Constructive alignment

Molecular Plant Biochemistry and Physiology course.

The constructive alignment between the course content, assessment and ILOs was pretty good. Moreover, there was a very good alignment between the course and the study program (MSc Programme in Biology – Biotechnology) ILOs. The course description and the study program description were written in exactly the same format.

ILOs of my lectures at this course were made in agreement with the ILOs of the course:

The aim of the lecture is to give the student a basic knowledge of metabolomics, an important research topic within modern science. The lecture will illustrate how novel technologies within metabolomics are used to produce coherent knowledge of complex biological systems. The use of the new knowledge in designing crop plants for the future using genetic engineering will be discussed.

After completion of the course the student should be able to:

- describe principles, applications and experimental setup in metabolomics
- identify specific problems within plant biology, which could be solved by metabolomics
- read scientific articles about application of metabolomics, interpret the results presented and take a critical and creative standpoint to the presented scientific problems.
- transfer theories and principles from metabolomics to solve new questions posed by the research community, industry and the society.

The Bioinformatics 2 course.

The course description was not as extensive and organized as for the Molecular Plant Biochemistry and Physiology course. This was thus not so easy to characterize the constructive alignment between the content, assessment and ILOs of the Bioinformatics 2 course. The ILOs of my lectures were the following:

The aim of this lecture is to give a student a deep insight into metabolomics with focus on untargeted metabolic profiling, following the introductory lecture about basics of metabolomics.

The lecture & exercises will demonstrate how plant-insect interactions can be elucidated by untargeted metabolic profiling. The use of the new knowledge in designing crop plants for the future will be discussed. The exercises deal with the procession of LC-MS data from plants & statistical analysis of the metabolite data.

After completion of the lecture the student should be able to:

- describe experimental setup in metabolomics
- identify specific problems within research, which could be solved by metabolomics
- use metabolomics as an integrated part of a research project
- read scientific articles about application of metabolomics, interpret the results presented & take a critical & creative standpoint to the presented scientific problems
- transfer theories & principles from metabolomics to solve new questions posed by the research community, industry & the society

Reflection on teaching and TLAs chosen

Molecular Plant Biochemistry and Physiology course

I met active and engaged students. They were willing to answer my questions and interrupting me sometimes with comments or asking unplanned questions. The questions asked by the students indicated that they could understand what I was talking about and that they were thinking in a global perspective about the applications of the knowledge obtained (evaluation category of the Blooms taxonomy). The course was based on the interactive teaching from the beginning; it was clear that the students were used to such a teaching. Thus, no effort was required from my side to make them active – I just had to keep their "active spirit" and enjoy them showing a lot of interest in the subject.

I did not experience silence and empty faces when asking questions. I could not see any "Roberts" in the class (Biggs and Tang; 2007). There were in general at least a couple of students wishing to answer individual questions. I tried to say "Good" or "Very good" every time to the student who answered the question and repeat the answer to the whole class.

The questionnaire answers by the students (Appendix A) indicated that the students were pretty good in finding the major points of the lecture. Some students have experienced particular difficulties with some points, which I would have to address better next time.

There was an abundance of individual questions in comparison with other activities during the lecture (which were the easiest TLAs to design), but the lecture worked fine. This made me think the plan with a lot of individual questions and not so many other kinds of TLAs was good enough to be repeated during the next course (Bioinformatics 2).

The Bioinformatics 2 course

I had an afternoon session with students that had a conventional (not interactive) morning lecture. The teacher from the morning session told me he did not have enough time for the material he was gonna give, so he went through everything very fast. I probably got tired students, which really needed some activation. But I did not adapt to the situation. I did not have a "plan B", so I went through my plan with abundant individual questions anyway. Only the first two individual questions were answered, the second one was answered incorrectly. This was the last time I have heard an answer, my next questions were not answered. I gave the students some time to think on the answers, but afterwards was starting to explain the answers by myself. In some cases I could see students showing their agreement with the explanation – as if this was what they thought by themselves. I am not sure this would help with providing the students more hints that could lead them to the answer, since the students seemed to not wanting talk, maybe being afraid of giving a wrong answer.

The situation required on-the-spot improvisation in response to the events occurred. For example, after not getting any answer to one of the individual questions, I could have asked the students to discuss it in groups for some time and then come with a "group answer". A very good response to a question when the students had to raise their hands to give a YES/NO answer was another indication that the students were at least sometimes too shy to give an individual answer. The fact that the majority of the students have generally pointed correctly at the major points of the lesson indicated that most of them could understand what I was talking about.

The lectures were mixed with 3 computer exercises (in the same computer room). We have experienced huge computer problems for the first of the practical computer exercises (not enough memory); that was not good for the general mood either. The fact that I have tested how the program works on one of the student computers in my building did apparently not help to prevent the problem – the student computers in the classroom had less memory.

Finally, my expectations to meet students that did not require too much activation (because my first students from the previous course were like that) and not being ready for a different scenario was a mistake.

Conclusions

The results of this small study were not surprising – they show that students learn best when they are actively involved in lectures. Students intensified their attention when active elements were present – it sharpened their focus on the lecture. This assumption is supported by the fact that students remembered much better the elements of the lecture included in different TLAs than in general explanation of the subject. This could be for instance seen in the answers to the “major points”-question of the questionnaire. Three students of the Bioinformatics 2 course, which did not seem to understand the main points of the lesson, mentioned some elements included in the TLAs as major points.

This small study shows that not all the activities are suitable for all types of students. Thus, the TLAs should be designed considering student groups with different responses and levels of activity. Student behaviour should be a basis for rethinking and re-planning a lesson. Good teachers should be sensitive to students in face-to-face instructional settings and frequently adjust the in-class presentation of course material in response to student questions, body language, and classroom mood. Good teachers should learn how to revise their delivery of class materials to capitalize on student interest and motivation, tailoring their lesson to the situation and learning opportunity at hand. For example ask the students to discuss the question in groups and then give a “group answer”, if the students do not answer an individual question. Individual questions is a good activity if the students are active and not shy. Otherwise more questions where students have to vote or raise their hands in order to choose the right answer are more appropriate. The voting could be made twice: after the first time the students get a chance to talk to each other about the answer they chose and then they vote again.

Many good examples of TLAs for interactive teaching are described by Fuller (1998) and in (Biggs and Tang; 2007, chapters 7 and 8, pp. 105–162). But most of them are suitable for a long-term teaching (not just one lesson as it was in my case). It is probably a good idea for a one-lesson teaching to start the lesson with some multiple-choice questions to understand “the level” of students (how much they know), and use the test as a basis for how the material should be delivered and which points require special attention.

A Appendix: Students' evaluation of Molecular Plant Biochemistry and Physiology".

STUDENTS' EVALUATION. Course "Molecular Plant Biochemistry and Physiology".

What were the most important points of this lecture?	**Did you have any particular difficulties during this lecture?**
Metabolic studies is a new area, but important! Can be used for different purposes, a lot like genetics I think.	Yes, a lot of new/difficult stuff (I am not studying biotechnology!). Especially the genetic/metabolic techniques are difficult, but I understood quite a lot and got the big picture I think.
- Techniques of metabolite profiling with different types – LC-MS, GC-MS, etc. - The way of analyzing the fragmentation to see the metabolite. - The softwares & which gives the quantification & the statistical analysis part to see the level of significance.	NO!
To get knowledge what is the metabolic profiling and how we use it in different types of investigations. What kind of data can we obtain and how to analyze it to get the information we are looking for.	No. All important informations were explained quite well.
That metabolomics can be used to identify relevant metabolites, in order to reveal certain plant properties. Especially it is a strong tool when used together with statistics and classical genomics.	I am not sure I understand the C part of the metabolic (LC-MS) profiles. But overall, the lecture was good and understandable.
- How metabolite analyses can be used in identifying e.g. resistance compounds in plants. - Which methods are applied for metabolomics analyses – LC-MS & GC-MS etc. for extraction and detection – and computer software for analysis of the different compounds.	- The genetics part (F2 question) was a bit difficult – far away, but it was very well explained. - Example 2 was not as understandable as example 1.
- Distinction of metabolomics from genomics and proteomics - The applications of metabolomics	- The genetics part (F1 vs F2) was a bit tricky, but you gave a good explanation. - Difference between GC, LC and CE.
- Good examples on what kind of results such analysis can give – Why make it? - The whole project: from starting material (F2) to the analysis methods to data analysis. - Nice overview.	The Principal Component Analysis
Good relevant examples which explain why metabolomics is a relevant and good tool to access new information about plants in relation to many factors which the plant is exposed to such as stress both abiotic and biotic.	I had difficulties with the PCA even through I have heard it before I have never understood it good enough but your explanation on how the PC1 and 2 is defined helped a bit.
- Than metabolomics will show a snapshot of the state of the organism, and that this metabolic state is continuously changing due to environment inside and outside the plant. - The applications of metabolomics.	The whole of example 2.

B Appendix: Students' evaluation of Bioinformatics 2.

STUDENTS' EVALUATION. Course "Bioinformatics 2".

What were the most important points of this lecture?	**What were the most important points of this lecture?**	**Are you considering using metabolomics/metabolic profiling in your (future) projects?**
Understanding of metabolomics and untargeted metabolic profiling. Learn how to use MetAlign program.	Computer problems, the 1st exercise.	Only if it is relevant for my projects, but it will not be focusing on metabolomics.
The difference between metabolomics and the more normal "-omics". Overview of experimental setup in this project. Point about F2 generation.	Computer problems. The F2 generation point was a bit tricky. Interpretation of MetAlign data.	Yes
Correlation. PCA. Clustering method. How to choose a group of metabolites to further looking up which correlate most with some phenotype feature	I like this lecture, I understand now basics of metabolite profiling. Negative was that exercise 1 didn't run – but it's not a teacher fault.	I have met 1st time this topic, but I found it very interesting and very informative. Yes, I am considering using these techniques in my future projects.
How you can obtain, detect, and analyze metabolites. It is a good idea to have mixed genotypes, e.g., in the correlation analysis. You can use correlation analysis and PCA to analyze the metabolics data and give a suggestion on which metabolites correlate with which biological condition.	No. Except that MetAlign didn't work.	No
The use of MS and MetAlign software.	Problems with the programme. Took too much time to get the results and the computer didn't have enough free space.	No…
How to use metabolic profiling in respect to problems in the true world.	The program doesn't seem to work properly on these computers.	Don't know what the future brings ;-)
Flow-chart: from problem to identification. Basic concepts of metabolomics including Eigenvector. Get a feeling of the software MetAlign.	No. Computer problems for the exercise.	Not at the moment. But it could be relevant later on and it is definitely interesting.
That you relatively easy can make an analysis of a metabolic profile! Nice!	Yes, never run locally on an old PC! But otherwise everything was very well described.	Maybe. If the right project comes along.
How to analyze results and how to use MetAlign. Last but not least the importance of using F2 plants when you want to analyze metabolites.	Nej, det var godt nok.	Niks, but it is very exiting.
The importance of using F2 plants. The technical details of MetAalign. The principles of a real metabolomics study. After 8 ☺	No	It could be nice to learn and use it in the future.

All contributions to this volume can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/2008-1/

The bibliography can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/kapitler/2008_vol1_bibliography.pdf/