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Curriculum Development, Alignment and Student Motivation in Molecular Systematics for students of Pharmaceutical Sciences

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Introduction

In the ideal world the student is motivated to learn by interest and the intellectual pleasure of learning associated with a high quality or deep learning approach. The responsibility for learning to happen can largely be handed over to the students and results are thereby improved. However, time pressure, the students preknowledge, interests, maturity, intellectual abilities, social background, self-efficacy etc. can lead to a learning approach characterized by external motivation. The student is then motivated to learn by the value of solving the problem, which is associated with a superficial or lower quality of learning.

Expectancy-value theory says that students are motivated to learn something if it is considered important to the student and the student also expects success when engaging in the learning activity. Effective teaching aims at helping the student to deep learning. Teaching theory and research has shown that deep learning largely depends on intended learning outcomes being clear and the student being motivated to reach them. Learning is also more efficient when students are activated by the learning activities. Other supporting conditions may be a trusting learning environment, using case based or problem based learning, and inspiration through the professional and encouraging engagement of the teacher (Biggs & Tang; 2007, ch.2–3, 7–8).

Aim and Objectives

The aim of the current project is to design curriculum for the subject Molecular Systematics as part of the BSc and MSc education in Pharmaceutical Sciences at the University of Copenhagen.

The project has three objectives:

1. To develop relevant curriculum and intended learning outcomes
2. To implement constructive alignment within and between BSc and MSc curriculum.
3. To implement student activation to improve learning efficiency and motivation

Curriculum and Intended Learning Outcomes

Teaching theory and research has shown that deep learning largely depends on intended learning outcomes being clear and the student being motivated to reach them. Intended Learning Outcomes (ILOs) can be defined as statements, written from the students perspective, indicating the level of understanding and performance the students are expected to achieve as a result of engaging in the teaching and learning experience (Biggs & Tang; 2007, ch.4). So we can ask, what are the students expected to learn, why and at what level of understanding?

Intended learning outcomes should ideally highlight qualitative understanding as for example defined by the SOLO taxonomy. The SOLO taxonomy (SOLO: structure of the observed learning outcome; Figure 19.1) provides a system for describing levels in approaches to learning from unistructural and multistructural to relational and extended abstract type knowledge or understanding (Biggs & Tang; 2007, ch.5). Furthermore, knowledge can be seen as declarative (academic) or functional (professional) depending on whether the theory component is a means in itself or a means to perform in a more informed or efficient way, which is often what professionals are expected to do after their education.

Intended Learning Outcomes for lecture in BSc course

From extracts of the course description of "Pharmacognosy and Natural Products Chemistry (M24-1)", objectives related to the plant systematics

	Quantitative		Qualitative	
Prestructural	Unistructural	Multistructural	Relational	Extended abstract
Misses point	Identify, do simple procedure	Enumerate, describe, list, combine, do algorithms	Compare/contrast, explain causes, analyse, relate, apply	Theorize, generalize, hypothesize, reflect

Fig. 19.1. The SOLO Taxonomy, modified from Biggs and Tang, chapter 5, figure 5.2.

part can be drawn: "An introduction to botanical classification systems (particularly molecular systematics) and aspects of basic botanical terminology, constitutes the theoretical background for understanding connection between biodiversity and chemical diversity for relevant groups of plants and natural products. Emphasis is placed on pharmaceutically relevant compounds". However, for the students it may not be clear what the objective of each element of the course is and what level of understanding and performance they are expected to achieve. New intended learning outcomes were therefore developed. The intended learning outcomes for the BSc lecture is to work with a case to:

1. *explain* in a few sentences what a phylogeny is and how a phylogeny can be obtained from DNA-sequence data of plants. (declarational and relational understanding).
2. *apply* the principle of monophyly to identify monophyletic clades on a phylogeny. (functional and relational understanding).
3. *explain why* there is a connection between DNA-based phylogenetic classification of plants and the chemical diversity of groups of plants (declarational and relational understanding).

Intended Learning Outcomes for seminar in the advanced MSc. course

The MSc curriculum offers the course FFKKM9041, Advanced Pharmacognosy and for the first time in 2010 a four hour seminar on Phylogenetic Selection was included. Intended learning outcomes was developed that would build on the objectives of the BSc course focusing on introducing the students to current research within the field. The intended learning outcomes for the MSc seminar is to work with a case and background theory in order to learn to:

1. *identify* the major critical tasks needed to carry out a phylogenetic analysis and *reflect* on the scientific quality of an actual phylogenetic analysis (declarative-functional and unistructural-relational knowledge)
2. *design* a basic phylogenetic study of DNA-sequences (functional, relational knowledge)
3. *reflect* on the potential of using phylogenies as selection tool in natural products drug discovery (declarative, extended abstract)

Constructive alignment

Based on constructivist theory learners construct their knowledge through their own activities. Intended outcomes should therefore *specify the activities* the students should engage in to achieve the intended outcome and the activities should be *aligned* to the intended outcomes. Likewise, intended learning outcomes, teaching and learning activities (TLAs) and assessment tasks should be aligned (Biggs & Tang; 2007, ch.4).

For example, one of the intended learning outcomes for the BSc lecture is to: "*apply* the principle of of monophyly to identify monophyletic clades on a phylogeny".

To engage the students in relevant learning activities, the students are presented with a phylogenetic tree of the angiosperms and asked to discuss if monocotyledons and dicotyledons are monophyletic on the displayed tree. The students thereby actively do what the intended learning outcome says. Likewise exam questions are designed to test if the student has achieved the intended learning outcomes. As part of a multiple choice exam, the students are for example presented with a cladogram of the Eudicots and must answer yes or no the question: "Rosidae (Rosids) are a monophyletic group".

Likewise, one of the intended learning outcomes for the MSc seminar is to: "*reflect* on the potential of using phylogenies as selection tool in natural products drug discovery"

In the beginning of the seminar, before the intended learning outcomes are presented, the students are asked: "Why do you think we have included a seminar on phylogenetics in this course?". During the seminar the students are presented with an example from the teacher's own research, which uses phylogenies as a selection tool as well as with a list of potential advantages of phylogenetic selection.

In the multiple choice exam, the students are then asked to answer yes or no to the statement: "Phylogenetic selection aims to identify the most interesting plants for further study."

Student Activating Teaching and Learning Activities

Students learn better when they are activated and actively work with the subject. Lectures are often structured with a very low or no degree of student activation, partly due to traditions, and partly due to the belief that it is close to impossible to activate students in a large-classroom or lecture situation. However, there is a range of activities that can be used even in a lecture situation to activate students such as asking questions and allowing time for individual reflection or discussion with the neighbor. Problem or case based learning ideally is well aligned to intended learning outcomes, has the potential to improve student motivation, to make connections to preknowledge, activate students and construct functioning knowledge (Biggs & Tang; 2007, ch.8–9).

To make connection to previous knowledge, the MSc seminar was opened with the question: "Do you have any previous knowledge of phylogeny?". Suggestions are written down on the board. The next questions are designed to motivate the students by reflecting on the relevance of the subject and by letting them take ownership of the intended learning outcome: "Why do you think we have included a seminar on phylogenetics in this course? What would you like to get out of today?". In the BSc course the relevance of the subject is instead listed upfront on the very first slide.

In both the BSc lecture and the MSc seminar, a case is introduced which forms the basis and provides a framework for the teaching and learning activities. In the BSc lecture, students are introduced to a news report from the Independent, which is handed out as reading preparation for the lecture. Together with the teacher, part of the lecture then focus on exploring the background for this news article as well as introduce the theory and methods of molecular systematics. In the MSc course, an article from the teachers own research is used to go through the intended learning outcomes. The article has been given to the students as preparation reading for the seminar.

In the end of both teaching sessions, students are asked to review what they have learned to improve lasting retention. An example of activities for review and self-evaluation is: "Make a few sentences, a list or a mind-map of the most important points in todays seminar. Then discuss with your mate and update your own points as relevant".

The MSc seminar is a teaching session of four hours. Effective learning is therefore supported by changing activities and activate through questions and interaction. The first part of the seminar is used for introduction to the subject and the case, then one hour is used to do a computer exercise in the databar. The students are given a protocol to follow which allows them to use the internet to find sequences related to the case in Genbank, do alignment and simple phylogenetic analysis and reflect on the results. The last part of the seminar is then used to explain how the phylogeny was used in the chosen case to identify promising candidates for traditional medicine and lead discovery.

Evaluation of MSc seminar

The seminar on the MSc. course was evaluated by the students at the end of the seminar using a questionnaire with three open questions evenly spaced on a single page handout.

1. Which parts of todays seminar did you like most and why?
2. Which parts were not so good and why?
3. Do you have any suggestions for improvement of the seminar in the future?

In summary, the majority of the students liked very much to work in the databar, but some felt there was too little time and a few felt they spent the time following the manual rather than reflect. They felt the practical exercise both helped them to understand the theory and get an idea about how much work is needed to produce a phylogeny. It was clear during the computerlab that some students found it very easy and others very difficult. One student pointed out that it is exiting that the teacher uses her own research as example. The concluding part helped everything fall into place. The specific part on the statistics and variety of methods for phylogenetic analysis was very hard to follow and most of the students felt it should be simpler rather than more detailed. In the future, the introduction to methods should be shortened and simplified, there should be more time in the databar, the manual should be uploaded to the course website before the seminar and perhaps there could be more time for the concluding part. It was also planned to give the students a case to reflect on towards the end, but it had to be skipped due to time pressure and it may be difficult to find time for this.

Examples of student comments:

> *"It gave a good introduction to the phylogenetic selection and what it could be used for."*
>
> *"Statistic methods. Not enough time to tell the whole story or learn it, but too detailed to be easy to understand. The computer part had a lot of learning to deal with the problem and less time to understand it."*
>
> *"Less about the statistics and more about the consequences of the statistics."*
>
> *"The practical part could be longer, but the practical guide for the computer was really clear."*
>
> *"I liked the practical part on the computer because it gave me a real view about phylogenetic work and I understand better the theoretical part."*
>
> *"Good to try and use the programs, gave a little feeling of how difficult it is, and gave a good felling when we got something out of it."*
>
> *"I discovered an interest in the subject today so it is good for me."*
>
> *"The most interesting: you´re speaking about your own work."*
>
> *"The conclusion (last part) was the most important. It was then everything fell into place."*

Discussion

Many new concepts on using preknowledge, student activation, interaction between student and teacher, case or problem based learning, self evaluation, explicit intended learning outcomes and constructive alignment was used. The students were generally happy with the structure and activities, but on the BSc lecture, all the great ideas, preplanning and structure impacted on the freedom to and expression of enthusiasm. A little less structure in the future will allow for more time to reflect, and more emphasis on what is the important take home messages. The MSc seminar was aligned to build on top of the intended learning outcomes of the BSc lecture, but the students preknowledge turned out to be less than expected and varied drastically between students. Half of the students on the MSc course were from abroad and had not followed the BSc course offered at FARMA. The theoretical introduction to phylogenetic analysis and the various methods was considered long and difficult by the students.

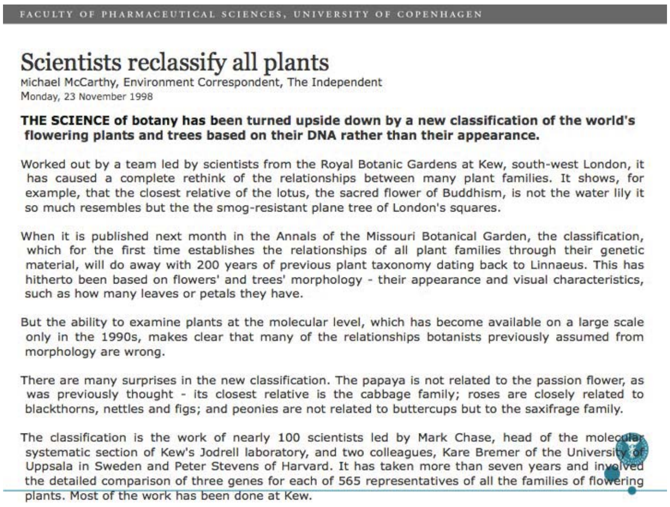
In conclusion, a major point to be learned is that it is difficult but important to make *realistic* intended learning objectives that are relevant to the students preknowledge and timeframe for the subject. Another important lesson learned is that less is better. It is very easy to overload the students with information, which they then have difficulties retaining. Based on the number of blanks in the multiple choice exam, the MSc students actually found phylogenetic selection the most difficult subject in the course.

However, all in all it was very exiting and inspiring for the teacher to experiment with a range of new concepts and teaching and learning activities and with more practice it is very likely that the use of relevant teaching and learning theories and practice can greatly improve the experience and the outcome of the teaching and learning activity. If the intended outcome is to make more efficient teaching and learning, the teacher needs to engage in relevant activities such as designing and practising efficient teaching.

Conclusions

New curriculum for the subject Molecular Systematics as part of the BSc and MSc education in the Pharmaceutical Sciences at the University of Copenhagen was designed and introduced. A range of theoretical and practical considerations for improving efficient teaching and learning were explored focusing on motivation and activation of the students. The new curriculum and activities are considered a great improvement on previous curriculum design, but the teaching and learning sessions can be further improved by reducing and simplifying the number of activities allowing for more flexibility and even more student activation, especially in the advanced MSC seminar. Just as students can, teachers can improve by practice.

A Example of slides used in the BSc lecture (1-3) and the MSc seminar (4-6).



Scientists reclassify all plants

Michael McCarthy, Environment Correspondent, The Independent
Monday, 23 November 1998

THE SCIENCE of botany has been turned upside down by a new classification of the world's flowering plants and trees based on their DNA rather than their appearance.

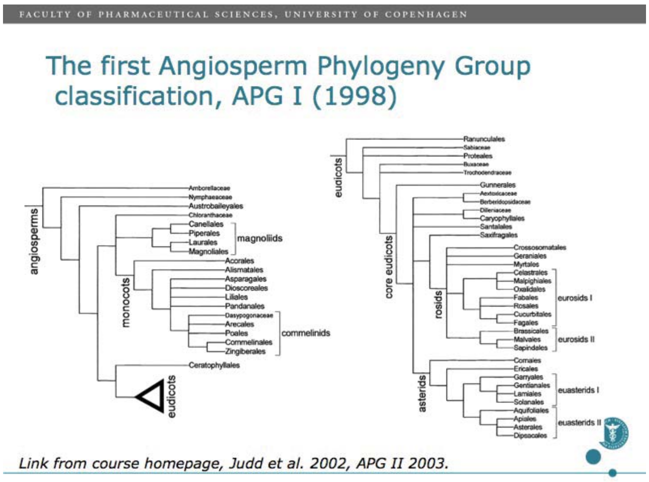
Worked out by a team led by scientists from the Royal Botanic Gardens at Kew, south-west London, it has caused a complete rethink of the relationships between many plant families. It shows, for example, that the closest relative of the lotus, the sacred flower of Buddhism, is not the water lily it so much resembles but the the smog-resistant plane tree of London's squares.

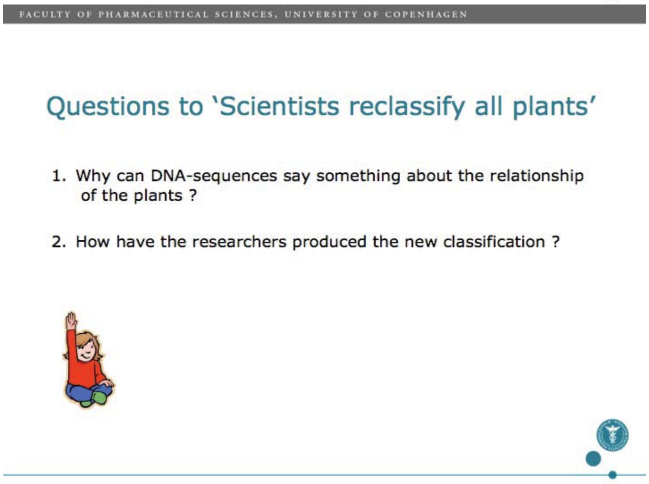
When it is published next month in the Annals of the Missouri Botanical Garden, the classification, which for the first time establishes the relationships of all plant families through their genetic material, will do away with 200 years of previous plant taxonomy dating back to Linnaeus. This has hitherto been based on flowers' and trees' morphology - their appearance and visual characteristics, such as how many leaves or petals they have.

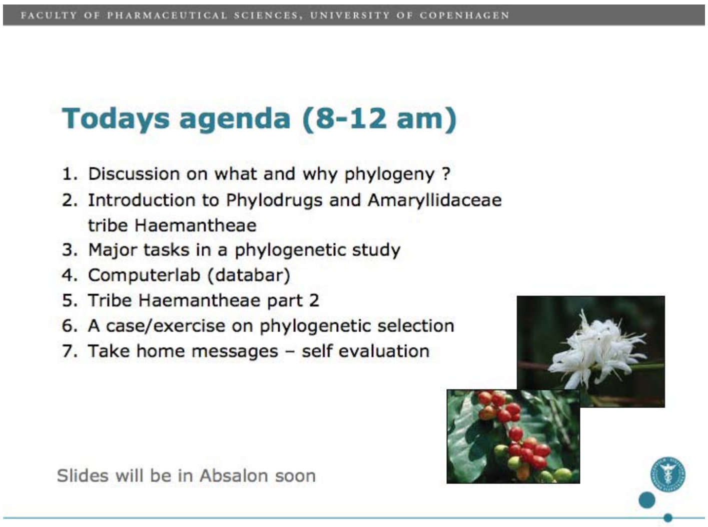
But the ability to examine plants at the molecular level, which has become available on a large scale only in the 1990s, makes clear that many of the relationships botanists previously assumed from morphology are wrong.

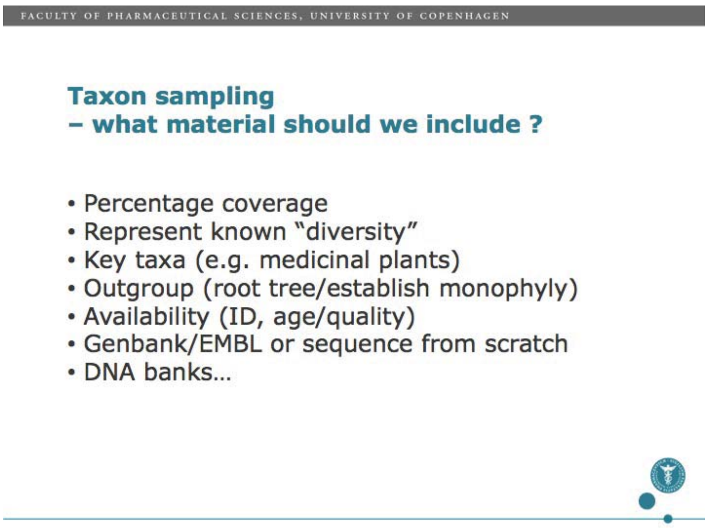
There are many surprises in the new classification. The papaya is not related to the passion flower, as was previously thought - its closest relative is the cabbage family; roses are closely related to blackthorns, nettles and figs; and peonies are not related to buttercups but to the saxifrage family.

The classification is the work of nearly 100 scientists led by Mark Chase, head of the molecular systematic section of Kew's Jodrell laboratory, and two colleagues, Kare Bremer of the University of Uppsala in Sweden and Peter Stevens of Harvard. It has taken more than seven years and involved the detailed comparison of three genes for each of 565 representatives of all the families of flowering plants. Most of the work has been done at Kew.









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