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# Formulating, aligning and implementing effective Intended Learning Objectives in a pre-existing course

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## Introduction

The term 'constructive alignment', coined by John Biggs (1996), is a form of outcomes-based education that aligns both the teaching and assessment of a course to its intended learning outcomes (ILOs). Designing a curriculum to ensure alignment between teaching / learning activities (TLAs), assessments and ILOs maximizes consistency and thereby the likelihood of achieving deeper, functioning knowledge in the students: the most desirable outcome of teaching. 'Traditional' university teaching, however, is typically not aligned. Norm-referenced grade measures and large classes necessitated by limited resources hinder implementation of constructively aligned courses. Additionally, courses that have run apparently successfully for many years may lead teachers to believe that improvement is not required (Biggs and Tang; 2007). This approach to tertiary level education follows the objectivist theory of teaching and learning, whereupon 'decontextualised' knowledge is learnt, examined and applied in what can be considered context-independent situations (1996). The role of the teacher here is simply to impart knowledge, and it is then the student's responsibility to record, remember and apply that knowledge. This is increasingly being perceived as no longer acceptable in higher educational practice, with constructivist learning theories gaining prominence. Constructivism is based upon the learner taking responsibility for their own learning, arriving at meaning and understanding through a combination of individual and group activities which allow them to construct knowledge. Through these processes, it is much more likely that the student will engage deeper learning approaches. The learner, then, takes the central role in constructivist educational environments: the 'constructive' part in 'constructive alignment'. The teacher maintains a fundamental role in providing learning situations and tasks that enable the students to achieve this higher level understanding, acting as a 'catalyst' (Biggs; 2003): this deals with the 'alignment' aspect. The teacher/s should therefore establish a framework where TLAs, teaching methods and assessments of a course are appropriate to facilitate attainment of the intended outcomes. In effect, involvement in such a course should render it highly difficult for the student to avoid learning. Under the traditional, objectivist approaches, students tend to target their learning toward the assessment. What the average student will learn is therefore determined by the examination content and method, resulting in largely in surface learning, e.g. memorizing course material in a decontextualised manner (Crooks; 1988). Creating a constructively aligned framework where surface learning will not suffice and in fact is actively difficult to pursue is therefore highly desirable.

How can such a framework for a programme be established? Biggs (2003) describes the stages as follows:

- Define optimal outcomes of the teaching, both in terms of content and level of understanding (ILOs)
- select TLAs appropriate to achievement of the ILOs;
- implement assessment activities that reveal how well the students met these ILOs; and
- award grades.

Design and implementation of ILOs are clearly the foundation in constructive alignment, be it at institute, programme or course level, and must precede the design of TLAs and assessments (Biggs and Tang; 2007). Consideration of these aspects will form the basis of this project.

## Project rationale

I 'inherited' the teaching of part of an MSc. course. I took the opportunity to re-structure the elements I was involved with (lecture, lab exercises and case studies) to try and make them coherent and aligned – with each other and with the exam. Several issues and questions were raised during this process:

- What constitutes effective ILOs?
- How can these be formulated and implemented?
- How to check whether or not the ILOs had been met.

Addressing these points leads to the pedagogical aims of the project associated with the teaching of the course:

- Design new and aligned ILOs
- Compare to existing ILOs
- Consider alignment with assessment methods.

## Course description

The course in question, *Heterologous Expression*, is part of the biology MSc. programme in Biotechnology (appendix 1). It carries 15 ECTS credits over one block of full-time study. My involvement was in teaching one of the expression systems. A different system was introduced every week, with each being taught by different teachers. There were 33 students participating in the course. Overall learning outcomes for the course were as follows:

The course should enable the students to appraise different systems available for heterologous expression of a gene leading to protein production, to select the most appropriate system, and to subsequently successfully implement that strategy. The summative assessment takes the form of a 30 minute oral examination at the end of the block of study.

The programme ILOs (Figure 14.1) clearly lack specificity for directing the teaching of the elements of which it is made. As a newcomer to teaching the programme, this made it difficult for me to design my teaching and to have it align with the other elements, and, importantly, with the assessment. The existing programme ILOs in the 'knowledge' category make surface level learning demands on the students: in the SOLO taxonomy, *describe* is a quantitative phase verb which requires only that the students increase their knowledge, but do not necessarily deepen understanding (Biggs and Tang; 2007). Other verbs used in the programme ILOs in the 'skills' and 'competences' categories are *use, design* and *transfer*. These address the acquisition of functional knowledge and demand higher level understanding from the students. These ILOs provide guidance as to what should be included in the teaching of the individual elements of the programme. In order that the students should be able to *design* strategies and *transfer* theories, for

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| Knowledge | **Describe** the main features of *E. coli*, *Bacillus*, *S. cerevisiae*, *P. pastoris*, mammalian cell lines, *Xenopus* oocytes, *Aspergillus* and plants as expression hosts<br>**Describe** the following parameters for the above mentioned expression systems: Expression levels, Type of post-translational modifications, Mechanisms for secretion of the product, Stability of the product, Stability of the transformed expression host, Methods commonly used for transformation, Strategies for optimization of the expression level and quality of the product. |
| Skills | **Use** the knowledge to design an appropriate strategy for the expression of the correct amount and quality of a given protein/peptide.<br>**Design** a strategy for creating an optimal genetically modified expression host in relation to reduction of proteases, improvement of secondary modifications and efficient compartmentalisation of the desired product. |
| Competences | **Transfer** theory and principles regarding the usefulness of different organisms as expression hosts to different work situations.<br>**Make ethical considerations** about the use of GM organisms for production of peptides and about the disease risks connected to a certain expression host. |

**Fig. 14.1.** Programme ILOs provided in the course description for students

example, they must be able to turn declarative knowledge into functional knowledge. The ILOs of the programme elements must therefore be appropriately designed. The general theory espoused by Biggs for setting ILOs within a constructively aligned framework involves thinking 'in terms of appropriate verbs' that indicate the level of understanding and performance to be achieved. These activities can then be incorporated into TLAs and assessments, ensuring constructive alignment. The topic (*Xenopus* oocytes as a system for heterologous expression), type of knowledge (some declarative; mostly functional) and level of understanding (higher level appropriate to an MSc. course) – prerequisites for ILOs - were already in place. Biggs and Tang (2007) suggest the following doctrine:

- Choose a verb at the appropriate level of understanding / performance expected;
- Specify the topic content addressed by the verb; and

- Specify the context of the knowledge which pertains to the verb.

As there were three different TLAs (lecture, journal club and lab exercises), the teaching could be viewed holistically when formulating the ILOs. The week was structured such that the lecture came first, followed by the start of the week-long lab exercises, with the journal club in the middle. The approach taken was that learning from the ILOs set for the lecture would be consolidated into functional knowledge during the other TLAs. Thus, bearing in mind the criteria given above, the following ILOs were formulated:

1. *Describe* the characteristics of the *Xenopus* oocyte system, giving advantages and limitations
2. *Compare and contrast Xenopus* oocytes as a heterologous expression system with other strategies
3. *Explain* the role of untranslated regions (UTRs) in heterologous expression systems
4. Be able to *design* a strategy to identify and characterise novel transporters.

Drawing from the SOLO taxonomy, *describe* represents a multistructural but quantitative phase ILO, whilst the remaining ILOs seek to engage learning in the qualitative phase, both relational (*compare and contrast, explain*) and extended abstract (*design*). The framework of the course encouraged the conversion of passive, declarative knowledge acquired in the lecture into functional knowledge through the preparation and performance of the other TLAs.

Success of the ILOs is ultimately judged through end-of-programme assessment. Small exercises were incorporated into the teaching that enabled me to check progress and understanding. For example, an exercise in which the students had to complete a table comparing elements of different expression systems during a lengthy incubation period of the lab exercise gave an indication of the whether or not ILO 2 had been achieved. The main assessment takes the form of a 30 minute oral exam at the end of the programme. One each of the practical and theoretical exercises, chosen randomly, are discussed, and the principles expected to be understood. An overview and sound comprehension of the topics covered throughout the course should be demonstrated, and links made by the student between the different course elements are sought for. Four students randomly drew the *Xenopus* lab report, and another five drew the case studies from the week to discuss. As a prerequisite, 75% of lab reports must be completed in order to attend the final exam. This means that, in theory, students having already satisfactorily passed all lab reports at the three quarters point of the course may be discouraged from handing in reports for the remaining classes, safe in the knowledge that they are not needed in order to pass. This highlights one unsatisfactory side of the assessment procedure. Oral exams are most commonly used in the defence of a thesis or dissertation, where the examiner has already seen the work under assessment. The interactive nature of the oral assessment allows the examiners to probe the students and uncover "unanticipated but valuable learning treasures" (Biggs and Tang; 2007) and allows the level of challenge to be tailored to fit each student. They are, however, time-consuming and teacher-intensive: two teachers and an external examiner took 2.5 days to examine 33 students. The notion of setting a written exam instead has been considered and discarded by the course leaders because it was felt that the oral assessment establishes immediate and clear differentiation between top and lower grade students. It also means that the constructive alignment possible between ILOs and the assessment is reduced to generic terms: being able to explain principles, understand theories, and compare and contrast the taught elements of the programme. The average score of the students on the course was 9.2.

There should ideally be three levels of alignment present in higher education environments: graduate attribute, programme and course ILOs (Biggs and Tang; 2007). Invariably, however, there are barriers to this. Jervis et al. (2005) found their efforts to achieve alignment for an undergraduate Biochemistry degree confounded by the absence of prerequisite courses and by an almost constant organizational change of the degree scheme. In fact, a report into how high-quality learning can be encouraged in higher education funded by the U.K. Economic and Social Research Council in 2003 suggests that the "application [of constructive alignment] in practice is not likely to be straightforward" (McCune; 2003). The present programme also demonstrates some of the difficulties involved in achieving constructive alignment, such as having a large number of teachers on a course who aren't necessarily aware of what is taught in the other elements, having a pre-determined and fixed framework for the teaching, and not having specific assessment requirements.

# A Appendix: Course description

**Heterologous Expression -** Course Description 2009/2010

***Details***
Department of Plant Biology and Biotechnology 80 %
Department of Basic Animal and Veterinary Sciences 12 %
Department of Food Science 8 %

***Earliest Possible Year*** MSc. 1 year to MSc. 2 year
***Duration*** One block

***Credits*** 15 (ECTS)
***Course Level*** MSc

***Examination*** Final Examination
oral examination
All aids allowed

Description of Examination: The student will be examined in one of the practical exercises as well as one of the theoretical cases. Following there will be a discussion where the selected topics are put into context with other topics from the course.

Weight: The final examination counts 100%

7-point scale, external examiner

***Requirement For Attending Exam***
75 % of the reports must be approved in order to attend the final exam.

***Organisation of Teaching***
The course contains both a theoretical part and a practical part which are closely connected. There will be lectures as well as student presentations based on cases and journals. Laboratory work is running several days a week for 6-7 weeks

***Block Placement*** Block 3
Week Structure: Outside schedule

***Teaching Language*** English

***Restrictions*** Max. 40 students (lab facilities)

***Course Contents***
The course will contain a theoretical part where most aspects of peptide and protein production in biological organisms will be discussed (see below). You will acquire knowledge on the variety of possible host organisms found in the different kingdoms. We will discuss the possibilities of designing and finding new suitable expression hosts.

Topics that will be covered in the theoretical part of the course: The intelligent choice of a host organism / Cloning strategies envisioned by an "in silico" multistep cloning / Promoter strength and induction / Copy number and silencing problems in heterologous hosts / Expression vectors / mRNA stability and introns / Choice of, and placement of purification tags / Stability of the product / Secretion of proteins and signal trapping / Post-translational modifications in different host organisms / Inclusion bodies and folding of proteins / Expression of membrane proteins compared to soluble proteins / Heterologous expression for production of antibodies / Expression of toxic proteins / Transient expression / Optimisation of expression level / Fermentation and large scale production.

In the practical part of the course we will work with a range of different expression organisms. These include Escherichia coli, Saccharomyces cerevisiae, Pichia pastoris, Xenopus oocytes and higher plants. We will transform them and determine the amount of produced protein, we will also discuss ways to optimize the expression level and finally prove that the expressed protein exhibit the desired function. In the practical part we will also cover a broad aspect of typical problems related to the production of recombinant protein.

Topics from the practical part of the course:
Expression and assembly of a multi subunit protein complex / The effect of alcohol and temperature on expression level / Expression of a secreted protein / Sub-cellular fractionation / Detection of post-translated modifications / The use of protein homologs from thermophilic bacteria /Yeast two-hybrid system/ Split-Ubiquitin system / Electrophysiological measurement on ion-channels/ Virus induced expression

***Teaching And Learning Methods***
The course contains both a theoretical part and a practical part. In the theoretical part there will be lectures as well as student presentations based on cases and journals. A practical laboratory part is running several days during most weeks. There is a close connection between the topics covered in the theoretical cases and the practical work. The course will be divided into smaller parts build upon the different expression organisms.

***Learning Outcome***
The production of technical enzymes as well as of peptide- and protein-based pharmaceuticals are in large scale being performed in specially designed host organisms. The aim of the course is to educate the students in processes associated with heterologous expression. The students will upon completion of this course be able to design and perform a strategy for the expression of a given gene. This includes considerations about amount, quality and downstream applications of the product.

<u>After completing the course the student should be able to:</u>
**Knowledge**:
-Describe the main features of E.coli, Bacillus, S.cereviiae, P.pastoris, mammalian cell lines, Xenopus oocytes, Aspergillus and plants as expression hosts
-Describe the following parameters for the above mentioned expression systems: Expression levels, Type of post-translationel modifications, Mechanisms for secretion of the product, Stability of the product, Stability of the transformed expression host, Methods commonly used for transformation, Strategies for optimization of the expression level and quality of the product.

**Skills**:
-Use the knowledge to design an appropriate strategy for the expression of the correct amount and quality of a given protein/peptide.
-Design a strategy for creating an optimal genetically modified expression host in relation to reduction of proteases, improvement of secondary modifications and efficient compartmentation of the desired product.

**Competences**:
-Transfer theory and principles regarding the usefulness of different organisms as expression hosts to different work situations.
-Make ethic considerations about the use of GM organisms for production of peptides and about the disease risks connected to a certain expression host.

***Course Literature***
The students will receive a collection of scientific papers together with the manuals for the laboratory part of the course.

***Course Scope***
lectures 24, practicals 140, Colloquia 28, preparation 103, project work 116, examination 1

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/