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TO DESIGN A NOVEL PROTEIN - A CONCIEVE-DESIGN-BUILD-OPERATE EXPERIENCE IN MOLECULAR BIOTECNOLOGY AT LINKÖPING UNIVERSITY.

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ABSTRACT

To practice Bioengineering, from idea to product, requires extensive laboratory efforts, and is seldom possible to do within the frame of a single lab course. To allow for the students to develop such expertise, we have designed an extended CDIO project, which is performed over three subsequent disciplinary linked courses: Gene Technology, Biomeasurement Technologies and Protein Engineering. In this CDIO project, the students themselves create, clone, express and functionally evaluate a mutant protein of medical relevance. Half of the ~60 students performed the functional evaluation as a self-directed laboratory project in close connection to a parallel course in Project Organization, whereas the other half functionally evaluated their proteins in a teacher-directed lab course. Higher-order cognitive skills in laboratory learning as judged by a Perry evaluation were improved during the project for all students, but in particular for those who performed the self-directed evaluation. Furthermore, the students judged their own professional competence to be significantly increased as a result of their taking part in the CDIO project.

INTRODUCTION

Knowledge in Protein Chemistry - relating protein structure with function - is urgently required in research and industry as a result of the genomic screens, and the subject recruits students from various backgrounds. The interdisciplinary nature within Life Sciences and the fast development within the area prompt a modernized educational approach adapted to the current professional requirements. The Bologna treaty puts stringent requirements on the time frame in which to achieve proficiency and independence in Protein Chemistry on both professional and scientific levels (3+2 yrs MSc; 3 yrs PhD). With increased student numbers and lower budgets, educatory efficiency requires an altered attitude towards learning among students as well as among educators. This creates an inspiring arena for pedagogical development (Collins, 2002). In the current work, we have explored ways to enhance professional and scientific proficiency by encouraging increased student-learning responsibility, in ways that can be applied also to other subjects. A major goal is to investigate the efficiency of different pedagogical strategies in laboratory learning in larger student groups.

BACKGROUND

The frame of this proposal is Linköping University (LiU), with a long inter-disciplinary tradition. Our aim has been to develop efficient learning strategies devoted to aspects of Protein Chemistry accessible only through experiments. Although partial information can be gained through visualisation of previously determined protein structures ´in silico´, the testing of a functional hypothesis requires accessibility to perform experiments on the protein in an experimental set-up. In the tradition of John Dewey (1916), who argues that information does not become knowledge until one can use it, we argue that laboratory-based training at highly cognitive learning levels is essential for the understanding and mastering of Protein Chemistry.

It is well known that inquiry-oriented laboratory learning offers unique possibilities to deepen learning levels, especially with openness in the choice of problem and methods, and by allowing for unexpected results (Schwab, 1962, Herron, 1971, Berg et al., 2003). Thus, the ideal laboratory task would seem to be that of investigating a protein as or within the research laboratory. With high teacher/student ratios, this has previously been feasible at many universities, but is now difficult with increased student numbers and lower budgets. A common and major challenge is now to adapt previous laboratory courses to 5-10-fold more students. Simplifying the laboratory tasks to cook-book level is most frequent in Europe today (Séré et al., 1998), but the feeling of discovery and problem-solving essential for effective learning will then inevitably be lost.

A major aim for student training in Bioengineering is to learn to understand protein functionality to such depths that will allow the design of novel proteins with new or enhanced biomedical properties. However, to design new proteins in the lab requires extensive laboratory efforts, and is seldom possible to do within the frame of a single lab course. To this end, we have developed a novel strategy for teaching that is described below.

OUR APPROACH

To enable the students to pursue the entire protein engineering process in a self-driven and self-evaluated process, we have established connections that link the lab courses of four subsequent courses in the Chemical Biology program: Gene Technology, Biomeasurement Technologies, Protein Chemistry and Protein Engineering. This approach allows for the students to create, clone, express and functionally evaluate a mutant protein of medical relevance. The mutation is chosen and cloned within the frames of the Gene Technology course, in Biomeasurement Technologies they learn how to analyse functionality, in Protein Chemistry they learn more about protein structure and stability, and, finally, in the Protein Engineering course, they express and characterize the protein they cloned initially. Ideally, the students will be able to analyse the same protein clone as the one they derived in the first course. Together, this sets the frame of the CDIO project.

The entire project is performed in a group of 60 students. Out of these, half of the students performed the functional evaluation as a self-directed project, where they were encouraged to themselves design an evaluation approach, including the methodological and experimental setup as well as the performance of the evaluation. The other half of the students performed the functional evaluation in a teacher-directed way, with certain strategies for evaluation already being pre-chosen and set up experimentally as station labs.

The self-directed students performed the lab course in close connection to a parallel course in Project Organization. In practice, this meant that the students also had to keep a budget over their time and laboratory expenses, as well as keep careful control of their lab progress. Each week, the students made a presentation for a Steering Board, which was designed to resemble similar groups in pharmaceutical industry. The students were also encouraged to observe the group dynamics during the course.

An important part of the course has been to encourage reflective learning. Reflection is crucial in the loop learning model presented by Kolb (testing-experience-reflection-generalization-testing), and which is applied in the CDIO concept. In particular, developing reflective practice is essential to refine laboratory experiences into deep learning, to achieve significant experimental results, and to develop the professionalism of a reflective practitioner. Although less than 10 years ago, the small Protein Engineering-courses allowed for intense student-teacher contacts, current larger student groups and the need to optimise resources promts us to find new ways to encourage and facilitate reflection. To meet this need, we have organised a Lab Reflection Room, where a lecturer is present for discussion at specific hours. The room is organised to provide a comfortable atmosphere, where feedback can be given and received, and where a hypothesis and its testing can be discussed in detail. The room is large enough to accommodate several groups working in parallel, with the teacher moving between groups for discussion. Students were at first slightly bewildered since the lecturer, using a reflective model for interaction, gave no yes/no answers. However, as the course progressed, the students responded with increased feeling of self-confidence, independence and authority, a feeling of personal and professional growth, as well as increased competence in handling open-ended experimental issues.

At the time of this writing, we are giving the course for the second time, and will present the results of careful evaluation during the CDIO meeting. Our evaluation from 2005, when the course was given the first time, showed that higher-order cognitive skills in laboratory learning as judged by a Perry evaluation were improved during the project for all students, but in particular for those who performed the self-directed evaluation. Furthermore, the students judged their own professional competence to be significantly increased in several important respects as a result of their taking part in the CDIO project.

CONCLUSIONS

A novel student-directed CDIO project in Protein Engineering at advanced levels has been designed, which is operable also in larger student groups, and which advances higher-order cognitive skills in laboratory learning as well as increased professional feeling of competence.

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