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SCAFFOLDING RESEARCH-LIKE LABORATORY PROJECTS FOR FIRST YEAR STUDENTS

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Research-based teaching is the cornerstone of university teaching and is exerted in many different ways. A central part of research-based teaching relates to the scaffolding of students work in inquiry-based projects and guiding them in making sense of and using research literature in relation to these inquiries. During the first years of university teaching, research-based teaching is often challenged since first-year students do not yet have the qualifications to work with an authentic research project. However, there are reasons to believe that a key to develop their sense of belonging to the specific academic field of science and technology at the university, is to include them in collaborative work with research-like methods and with content from current and authentic research. The present paper discusses findings from re-designing two first year courses in chemistry and biotechnology, respectively. Both courses are situated in the second semester and students are expected to work with authentic research in the form of research papers and engage in laboratory work with research-like activities. The courses have been redesigned informed by e. g. previous course evaluations from students. Applying a design-based research methodology, the redesigns are illustrated, substantiated and discussed in the first part of the findings. Following this, data from pre- and post-lab questionnaires are presented discussing what the students report as outcomes/challenges. The findings will be discussed in relation to the development of students sense of belonging to the field of science and technology and of graduate attributes such as collaboration and experimental design.

Keywords: Laboratory work in science, higher education, learning communities

INTRODUCTION

First year university students' retention to the university and to the field of science and technology studies in particular is heavily discussed. Tinto (2017) suggests a focus on how to support persistence emphasizing the first-year students' sense of belonging. Understanding students' persistence can be approached by theories about intrinsic motivation referring to their experience of competence, autonomy and also relatedness (Ryan & Deci, 2017), the latter close to sense of belonging. Sense of belonging is a complex construct dependent both on efficacy beliefs before entering the university and their experience of being invited into a community of practice cooperating with other students and academics (Tinto, 2017). The present paper focuses on the sense of belonging specifically in the context of laboratory intensive science and technology disciplines. Previous educational development at our university has evidenced how redesign of laboratory exercises from cookbook-like instructions to learning designs including aspects of guided inquiry can successfully stimulate student-student dialogue on course content and interactions with the academic staff (Nielsen & Hougaard, 2018). These projects also show results in line with international research highlighting the potential of inquiry-oriented projects in the laboratory to engage students with the content (Hofstein & Kind, 2012). But referring to Healy (2005) research-like approaches at the university is both about scaffolding students in working inquiry-oriented, and guiding them in making sense of and using research literature. Evaluation of courses at

our university, where first-year students are working with primary research literature and with laboratory work referring to this, do however show some challenges. The present research refers to two specific courses “Introduction to Chemistry research” and “Biotechnological project”. There are specific issues in the courses, but across courses a generic challenge is to engage first-year students with very complex content and research-like methods. The dilemma is that they do not yet have the qualifications to work with authentic research, but there are reasons to believe that a key to their sense of belonging exactly is to scaffold them in collaboratively working with research-like methods and with content from cutting-edge research (Reid & Shah, 2007).

Research questions

- How can first year courses at science and technology be (re)designed targeting students’ peer collaboration in research-like projects?
 - What specific aspects of the dilemma of involving first year students in research can be identified in the two courses “Introduction to Chemistry research” and “Biotechnological project” and how do this inform a re-design of the courses?
 - What do the students report as outcomes/challenges in the two cases of re-designs?
 - How can the students’ experiences from the first year at university and their reflections about specific outcomes/challenges from working research-like be interpreted in terms of their sense of belonging to the university and to the field of science and technology?

METHODS

The project operates with an iterative approach to design, analysis and re-design (design based research: Barab & Squire, 2004). Two courses have been redesigned in collaboration between educational developers and academics staff from the departments, e.g. informed by data from both previous evaluations and research in science education. Results are presented below. The next step referring to the last part of the research question includes data which is currently being collected. Both courses are situated in the second semester at the first year rendering it possible in the pre-questionnaire to ask for students experience of self-efficacy, collaboration and perceptions of the particular field of science studies from their first half year at the university. The pre-questionnaire is distributed to all students at the two courses February 2019 (n=120). In the post questionnaire distributed at the end of the semester May 2019 the mentioned items are repeated and students are furthermore asked about perceived outcomes, and focused questions referring to key elements of the two redesigns are included, relating e.g. to their experiences from working with cutting-edge research. Questionnaires include both closed categories and open reflections. The open reflections are analyzed using thematic analysis (Braun & Clarke, 2006). Data to answer the last part of the research question will be presented at the conference.

RESULTS

To compare the two learning designs the students’ work during each laboratory course has been divided into four stages: 1) Preparation, 2) Experimental design, 3) Investigation, and 4) Report (figure 1). Intentionally, these stages reflect the stages in an authentic research project. In "Introduction to Chemistry research", the intention is, that students gain experience with cutting-edge research in an authentic research laboratory. The objectives relate primarily to the nature of chemistry research, and students’ collaboration with researchers. The course is organized with a preparation phase where students hear about cutting-edge research through a series of invited lectures. The course coordinator assigns two experiments, offered by different research groups to groups of 2-4 students. In most cases, the experiment is described in a partly cook-book like manual, which the student should read before coming to the lab. The students do not necessarily engage in any activities related to experimental design. During the investigation phase, the students work on two consecutive, but typically unrelated, experiments in two different research groups, each reported in a lab report.

Our analysis showed that although the students work in an authentic research context, the Preparation and Experiment phases include only limited research-like tasks. As a first attempt to scaffold research like tasks and establish a learning community between students, three collaborative tasks were designed. First, during the preparation stage, a cooperative learning activity focusing on the reading and sharing of a research paper related to each of the assigned projects. During phase 3 (Investigation), each student group is asked to present their findings from Project 1 to peers, and peer-feedback is provided referring to specific criteria. During phase four (Report), each student group hand-in a report and receive peer-feedback based on a rubric.

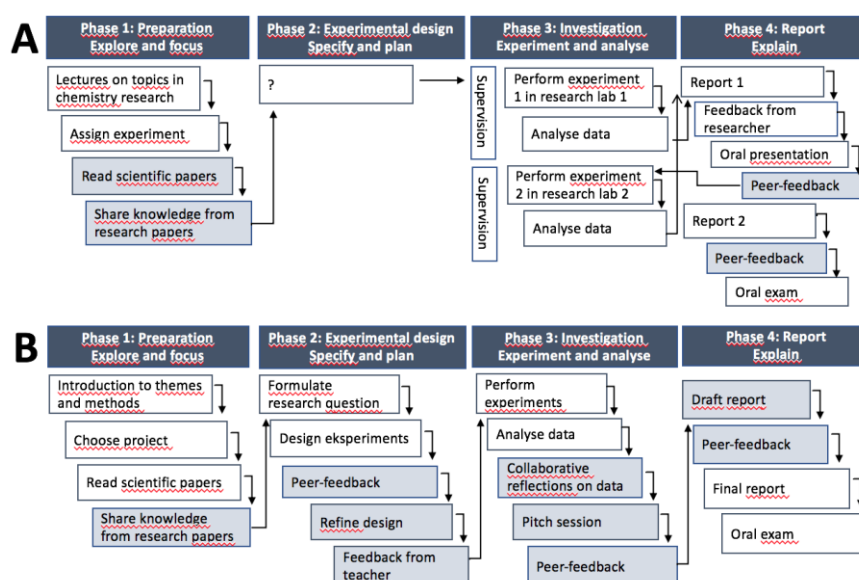


Figure 1. A schematic representation of students' tasks during the four phases of the redesigned courses: A. "Introduction to Chemistry Research" and B. Biotechnology project". Light blue boxes represent tasks added in the redesign process.

"Biotechnological project", at the department of Engineering, is organized primarily as project-based learning. Students choose between different projects and read research literature in the preparation phase. During the experimental design phase student-groups make a project plan - executed during the Investigation phase under guidance (figure 1B). Previous experiences showed students' difficulties in reading and applying the research papers in their projects and reports, and that many experimental designs were overruled by the educator due to practical issues related to availability of materials and equipment. The redesign focuses on scaffolding inquiry and collaboration by including collaborative activities in all four phases of the project. Particular effort is put into the experimental design phase, where students work on designing the experimental setup.

DISCUSSION

Analysis of the two courses demonstrated only a few learning tasks with research-like activities. And, there was no robust scaffolding of the inquiry-based activities evidenced in previous research to be crucial (Authors, 2018; Hofstein & Kind, 2018). Both redesigns focus on a series of collaborative activities where students engage in research-like activities including working with research literature, designing experiments, analyzing, and reporting data. Explicit scaffolding of cooperative learning and peer-feedback activities has been added. Students' experiences, i.e. in terms of sense of belonging, will be discussed at the conference.

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