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Research- and Problem-Based Learning as a Valuable Tool in Biotechnology Education

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I. Introduction

Microbial biotechnology (LÍÖ1106) and Applied project (HVN0186) are third year undergraduate courses at University of Akureyri (UNAK) within the natural resource and health related biotechnology programs. The laboratory section of these courses centers heavily around students taking part in the research process, requiring them to plan and execute projects in line with open ended prompts. Most recent examples include bioprospecting for proteolytic and saccharolytic bacteria, as well as diazotrophs and organisms capable of synthesizing biodegradable polyesters.

Students are guided towards activities intended to mirror authentic scientific work with an emphasis on students taking ownership of tasks related to experimental design, data collection (including but not limited to sampling, isolating pure cultures, and subsequent screening for and identification of desirable traits), analysis and presentation. Students summarize their work in the form of either a manuscript for publishing (peer-reviewed, undergraduate journal), or a research fund grant application, the latter which has historically mimicked that of the Icelandic Research Fund (Rannís). Additionally, students deliver mid semester oral presentations.

The role of the instructor is no longer to ”lead and feed [information]” but rather provide support and structure on a need-to-basis while facilitating transfer of skills and fostering an atmosphere of learning and student autonomy. Ultimately, the aim is to activate higher-order cognitive skills such as application, evaluation, and creation (see Bloom’s Taxonomy) while gaining valuable, hands-on experience within the laboratory setting and the student’s zone of proximal development (ZPD) during research- and problem-based learning (RBL and PBL, respectively).

This work reflects on the pedagogical approaches applied as well as challenges and opportunities of said courses which have been gathered by the author through means of observation and reflective practice.

II. Methods

Students and their work was observed in its natural setting within the laboratory and during regular student-centered meetings. Classroom observations were supplemented with information obtained from classroom discourse. Similarly, the author engaged in reflective practice (drawing from the works of Gibbs).

III. Results

From the instructor’s point of view, both courses have the potential of supporting and promoting student empowerment, ownership, responsibility, and autonomy as well as intrinsic motivation, cognitive transfer, active participation, critical evaluation and reflection and other 21st century skills.

Formative assessment is applied over the course of the semester, such that students frequently receive both verbal and written feedback as they engage in research activities. They are expected to hand in manuscript/application drafts prior to their final, end-of-semester submissions which typically increases the quality of the final “product”. It is worth noting that while students are not required to submit their manuscripts to a scientific journal at the end of the semester, it is generally around one fifth of the class that generates written work with potential for publication. Undergraduate, peer-reviewed journals such as Fine Focus (Ball State University, Indiana, US) offer a great avenue for undergraduate students to experience the process of publishing a scientific article from start to finish.

Observations and informal discussions with students have revealed several challenges including perceived lack of course structure (compared to other lab-based courses where manuals and step-by-step directions are provided at the beginning of the semester), and increased material complexity (which is often perceived as being outside of the students’ own ZPD). In particular, students note challenges related to effective time management and organizing multiple complex tasks in parallel.

Another commonly reported experience by the students pertains to problems with transferring methods described in the literature into the laboratory and method development/modification. Typically, as the courses proceed, a trend can be observed where students revisit methods from earlier courses on their own (such as genetics, microbiology and biochemistry) and apply them to these new research scenarios.

IV. Discussion

Research- based learning is a relatively new field within pedagogy, dating back to the mid 1990s. It is in line with the teachings of Dewey, Freire, and others that advocate(d) for instructional models that emphasize student engagement through tasks such as critical investigation of real problems. Problem-based learning, however, predates RBL by several decades as it originated within medical education in the 1950s.

As student challenges are based on informal conversations with students that have successfully completed the course, a more structured, qualitative study should be undertaken to better describe student perceptions of research- and problem-based learning with the end goal of improving and better facilitating students' learning. This might include identifying critical extraneous cognitive load points. For example, the Classroom Observation Protocol for Undergraduate STEM (COPUS) could be used to facilitate structured coding of classroom activities. Similarly, university level educators using RBL and/or PBL at Icelandic higher education institutions (HEIs) could be sought out, surveyed and interviewed on the same topic. The aim of this inquiry would be to highlight the opportunities and challenges of RBL/PBL at the undergraduate level in the Icelandic HEI environment, provide guidance to university educators thinking of embarking on the path of RBL/PBL, and provide the teaching community with a summary of best practices drawing from what has already been undertaken locally in terms of RBL/PBL.

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