June 2020

PBL at Department of Chemistry and Bioscience

Studyboard for Chemistry, Biotechnology and Environmental Engineering

Content

1. Purpose

This is an addendum to 'the booklet about PBL at Aalborg University
https://www.en.aau.dk/about-aau/aalborg-model-problem-based-learning
and was in its first versions prepared at Section of Biotechnology during Fall 2018.

The purpose is multi-fold

- to provide self-reflecting internal discussions at BIO on how PBL is conducted, embedded, and secured at the department
- to extrapolate the principles and objectives of PBL description for the entire university into the everyday teaching and supervision activities at BIO
- to give an introduction to practical implementation of PBL in the activities at BIO and guide new employees in parallel with the centralized PBL introduction courses
- to provide a starting point for the description of PBL learning outcomes in the curricula of all study programs

2. Activities at BIO where PBL learning objectives are specified, and provide students with progressively increased PBL competences

At BIO, PBL is a methodology that leads and supports the learning process within concrete disciplines and subject areas in science and technology. Students will via project work progressively increase their personal PBL competences.

At BIO, particularly the student projects ensure a continuous and extensive PBL component within all study programs. Students at all semesters work with PBL in their projects. These encompass 50% or more of the activities at all educational programs. PBL components are, to various extends, also brought into play in courses, e.g. in exercises, workshops or mini-projects.

Student projects include project work and are based on a problem. Project proposals are normally presented in a catalogue at the beginning of the semester. Problems are not explicitly described in the project proposals, but they are formulated in such ways that students can work out one or more problem encompassed within the project proposal.

- Project proposals include one og more open, unresolved question(s)
- The unresolved question has sufficient complexity allowing the student to analyse the question and define the actual problem that will become the underlying foundation of the project work
- Projects are proposed in areas and with sufficient complexity that allow students the fulfil the learning goals described in the curriculum via analyses of the question(s) and efforts to solve the problem

Student projects

- include unresolved questions with relevant scopes reaching beyond the narrow learning purpose for the student to ensure that the problems become authentic (after the 3rd semester, questions should be unresolved not only for the students but also for the supervisors)
- include questions that can be analysed and targeted by generally applicable methodologies to ensure that the project work becomes exemplary
- may address problems of relevance to external partners or being of relevance to research at BIO. Inclusion of students within ongoing research is a stronghold at BIO
- can address concrete problems where specific and possibly innovative solutions are targeted while still being comprehensible also on a theoretical foundation
- can also lead to problems, where the target will be e.g. new knowledge or new methodologies within a certain discipline

One consequence of working with authentic problems is that students also target their problem in an authentic manner. The aim of the project work is therefore to identify and address the problem and seek relevant answers and solutions, which can be based on theory and experimental work (laboratory work, field studies, simulations etc.). PBL competences are progressively acquired indirectly via the project work and include the ability to analyse concrete as well as theoretical questions, narrow down the specific problem that will be addressed, acquire new knowledge and needed skills, visualize, report, and discuss knowledge and results, and engage in evidence based discussions. This progression is reflected by the learning outcomes as described in the curricula.

The educational programs at BIO are all experimentally founded. Most student projects therefore include extensive experimental components. Competencies such as planning, selecting and designing experimental work and analytical programs, and utilization and evaluation of own results to ensure proper progression of the project work, are therefore central PBL competences progressively obtained via project work. Our expectations to the overall activities and outcomes of student projects must take the magnitude of the experimental components into consideration.

A specific objective of working with authentic problems is for the students to relate the problem itself and results and solutions to relevant contexts. At BIO, relevant contexts are always found within natural or technical (engineering) sciences and often also within social sciences, humanities and elsewhere, reflecting the globalization of science and technology. The relevant contexts can

for some problems be quite narrow while for others very broad. Relating problems and solutions to the relevant contexts is an essential PBL competence progressively gained during project works.

Project work at BIO is normally organized in groups of 4-7 students, with the exception of Master's projects that are carried out by 1-3 students. The organization of project work in groups of students allows every student access to peer learning and feedback to an extent that vastly exceeds interactions with their supervisor. Collaborative work will also provide students social competences and the skills to interact professionally with other individuals.

Project work is organized, managed and driven by the students, as they retain the main responsibility for their own learning process. Projects at BIO are therefore supervised in a manner that provides students a large degree of freedom allowing students to aquire competences within project organization and management. These competences include safety in the laboratory and in the field. The supervisor remains, however, the overall responsibility for safety in the laboratory and in the field, and the supervisor also remains the right to control and regulate access to laboratory facilities including equipment, chemicals, and consumables.

Students progressively expand their PBL competences. Project work must therefore be understood from the level of PBL competences, which have been gained at the given semester. The complexity of the project work and the freedom to analyse and select problems will therefore increase from semester to semester, and so will the expectations to all aspects of the project work and its results.

2. Glossary of central PBL terms

Project work – A project is a goal oriented process limited in time. At BIO, this is limited to one semester except for the final semester project, which is 2 semesters. The project is both the means through which the students address the problem and the means by which students achieve the learning objectives. The majority of the projects are conducted in groups (the project group). The students manage the project and they support each other in achieving the learning objectives. The collaboration includes knowledge sharing, task distribution, planning of experiments (including lab safety), group decision making, subject based discussions and critical feedback.
Problem - A "Problem" sense cannot have an already known or realized exact result – it must be complex enough to involve synthesis of not prior known or realized knowledge. This complexity must be understood from the level of the student. The 'problem' can be a concrete problem that needs a solution, or it can be a scientific question that is benefitting from new and increased knowledge and insights.
Authentic - Authentic implies that the problem is of relevance "outside academia". At BIO this means that authentic problems are of relevance also outside the department, and that the projects have relevance that reaches beyond the narrow learning purpose for the students. It does not imply that external partners always should be part of the project. It merely implies that the project is relevant also to external partners. Engagement of students in ongoing research at the

department, which predominantly has an applied perspective, is one of the strongholds at BIO (more under external partners).

Theory – Should be understood broadly and includes a wide range of fundamental knowledge and causalities underpinning the problem from very precisely described and verified theory such as equations to mathematical modelling of physical, chemical and biological systems to less well described theory that have more character of suggested hypotheses and where alternative hypotheses may exist.

Scientifically based - Implies that the problem is comprehensible, can be theoretically grounded and may be analysed and solved, taking an interdisciplinary approach.

Interdisciplinary approach – This should be understood broadly. Interdisciplinary can be encompassing two or more disciplines as close as protein chemistry and molecular biology, but can also include much more distant disciplinary such as cellular chemistry and electronics. Importantly is that the problem central to the project is complex enough to necessitate an interdisciplinary approach to analyse properly.

Research based knowledge – The definition of research based knowledge is subject of great debate. In this context, we will limit ourselves to state that research based knowledge includes specialized *state of the art* knowledge as well as development within a specific field, evidence based (including best practice) knowledge and experimentally verified knowledge.

Analytical – A systematic and logical approach to resolve problems and to identify causation and results, but also to anticipate unexpected results. To manage issues by drawing on research based knowledge and often perform experiments (in the laboratory, in the field or *in-silico*) to verify or falsify hypotheses.

Result oriented – A goal oriented process that at BIO is always based on analytical approaches.

Academic discussion – A subject based discussion, where arguments should be based upon basic or research based knowledge, with reference to scientific literature. Literature references should be understood from the level of the students (according to Qualifications Framework for Danish Higher Education, the use of original literature should e.g. be enforced at the MSc level).

External partners – From the view of the project, external partners is every actor outside the student group and their supervisor. This includes external organizations (see more under external organization), other student groups, other research projects and individual researchers (in addition to the supervisor).

Exemplary - Students project work must be exemplary with regards to content as well as approach. Exemplarity implies that learning outcomes achieved during project work are transferable to similar situations encountered by students in their subsequent professional careers. This requires that the students understand the context of the problem and of the scope of the conclusions reached by the group. The exemplarity of the project ensures that through their project work, the students will acquire knowledge, skills and competences which are applicable in a wider context than that of the project itself.

Context – Formally a context is the situation within which something exists or happens, and that can help explain it. To be relevant for the specific learning objectives in the curricula, the situation in question is of professionally relevance to the competence profile of the educational program. Relevant contexts can also be within broader fields of technical or natural sciences or within

"social" or "societal" sciences (see more under social) issues, or the relevant context of "the problem" can be of general relevance to society reaching beyond the field of science. This must be understood broadly and includes the element of exemplarity – that it is of relevance to the students subsequent careers. Therefore, context relevant to biotechnology can be more appropriately defined as "biotechnology in society". In order to understand the role of biotechnology in society, profound applied biotechnology knowledge is needed. From a teaching/supervisor point of view, this knowledge and experience obtained through applied research collaboration with external partners.

Knowledge, skills and competences – is described (in Danish) here: https://ufm.dk/uddannelse/anerkendelse-og-dokumentation/dokumentation/kvalifikationsrammer/begreber.

Translated loosely here:

Knowledge. Knowledge includes both facts and understanding and encompasses the following. The type of knowledge: best practice or theoretically grounded. The context of knowledge: within a subject, a subject area or within a profession. The complexity of knowledge: the degree of complexity and the different situations (predictable and unpredictable) this knowledge is relevant within. Understanding: the ability to put knowledge in context. E.g. understanding is expressed when you have to explain something to somebody else.

Skills. Skills describes the ability of a person to do something. It includes the following aspects: The type of skills: practical, cognitive (including analytical) or communicative. The complexity of the problem and the type of problem the skill is applied to. Communication: the type of communication needed, the complexity of the message, the target group and the means of communication.

Competences. Competences is about responsibility and independence. It describes the ability to use knowledge and skills in a study- or working situation. It encompasses the following. Awareness of the room to manoeuvre. Within which situations are the skills and competences relevant to use, and the degree of unpredictability and changeability of these situations. Collaboration and responsibility. The ability to assume responsibility for your own and other peoples work, and command the complex working situations one can be part of. Learning: the ability of taking responsibility for your own and other peoples learning.

Critical self-reflection - The process of questioning one's own assumption, presuppositions, and meaning perspectives. It the context of project work it also includes the ability to analyse past behaviour, contribution, engagement, and role within the student group with the objective of knowingly adjusting for subsequent project work to develop a best practice.

Supervisor – A teacher who facilitates that the requirements of the PBL process is met. This includes both procedure, learning objectives and exemplarity of the project, as well as supervising lab experiments (including lab safety). The supervisor also serves as consultant for the group for challenges relevant for the project. The supervisor is only available for the group for a limited time.

Individual assessment – Implies that each student in a student group is graded individually. Grading is given on the basis of a common report and the examination. The examination includes both a common round, where all students in a group can contribute and sequential individual

rounds, where only a single student can participate for a limited time. Both the quality of the report and the performance at the examination is combined in the grading.

External organizations – Implies institutional actors outside university. It encompasses private and public companies, foundations, NGOs, societies and the like.

Social – Relations and interactions between people. Society is the place where social interactions occur. Education and research at BIO have social and societal relevance at least in two aspects; one is that our knowledge, engineering and technology have the capability to change the nature and society, which need cautions on ethics, safety, biodiversity, sustainability etc. The second is that the skills and competences of our students and graduates need to pace the change and new requirements of the world and society e.g. moving from fossil energy and products to renewable energy and products.