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Digital Transformation at Aalborg University: Interdisciplinary Problem- and Project-Based Learning in a Post-Digital Age

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ABSTRACT

Since its establishment in 1974, Aalborg University has aimed to deliver cutting-edge research and innovative practices in engineering education. However, increasing complexity related to rapid developments in digitalization and emerging societal challenges offer new opportunities, requirements, and expectations across disciplines for educational institutions and staff to develop and adapt to an unpredictable and ever-changing future. This paper proposes a systemic approach to addressing these challenges in higher education and presents recent initiatives launched at AAU including a coming Institute of Advanced Study in PBL to support the digital transformation of problem- and project-based learning for the future.

Key words: digital transformation, problem-based learning, interdisciplinarity

A STRONG PBL TRADITION

From the very beginning, AAU has aimed to be at the forefront of educational innovation. Building on problem-based learning (PBL) approaches (Spaulding, 1969), the university developed its pedagogic approach, today known as problem- and project-based learning (Kolmos & de Graaff, 2014). During the

past 30 years, the response from society has been very positive with Danish science and technology companies ranking AAU high with regard to meeting societal and industrial needs (Christensen, Delahousse, Didier, Meganck, & Murphy, 2018 and Dansk Industri, 2018). Furthermore, AAU is recognized internationally for its research and innovative pedagogical approach and considered among current leaders in innovative engineering education (Graham, 2018), ranking number 6 in the world and best in Europe within Engineering in the *U.S. News & World Report* in 2017–2021 (Aalborg University, 2021), among the top 200 (~207) in the *Times Higher Education World University Rankings* (Aalborg University, 2021), and best on SDG4 'Quality Education' in Times Higher Education Impact Ranking (Times, 2020).

Today, AAU has three campuses, five faculties, and more than 22,000 students in total, with around 8,000 in engineering and science programs (Aalborg University, 2020). The AAU PBL model and curricula is designed around the AAU Study Activity Model (see figure 1) combining traditional discipline-specific course formats such as lecturing, labs and exercises, and online and blended courses with extensive student-led team-based project work (50% of students' time) assessed by oral, group-based defenses.

In problem-based project work at AAU, all problem-solving phases are emphasized, including identification, analysis, solving and documentation, and the student teams generally define the

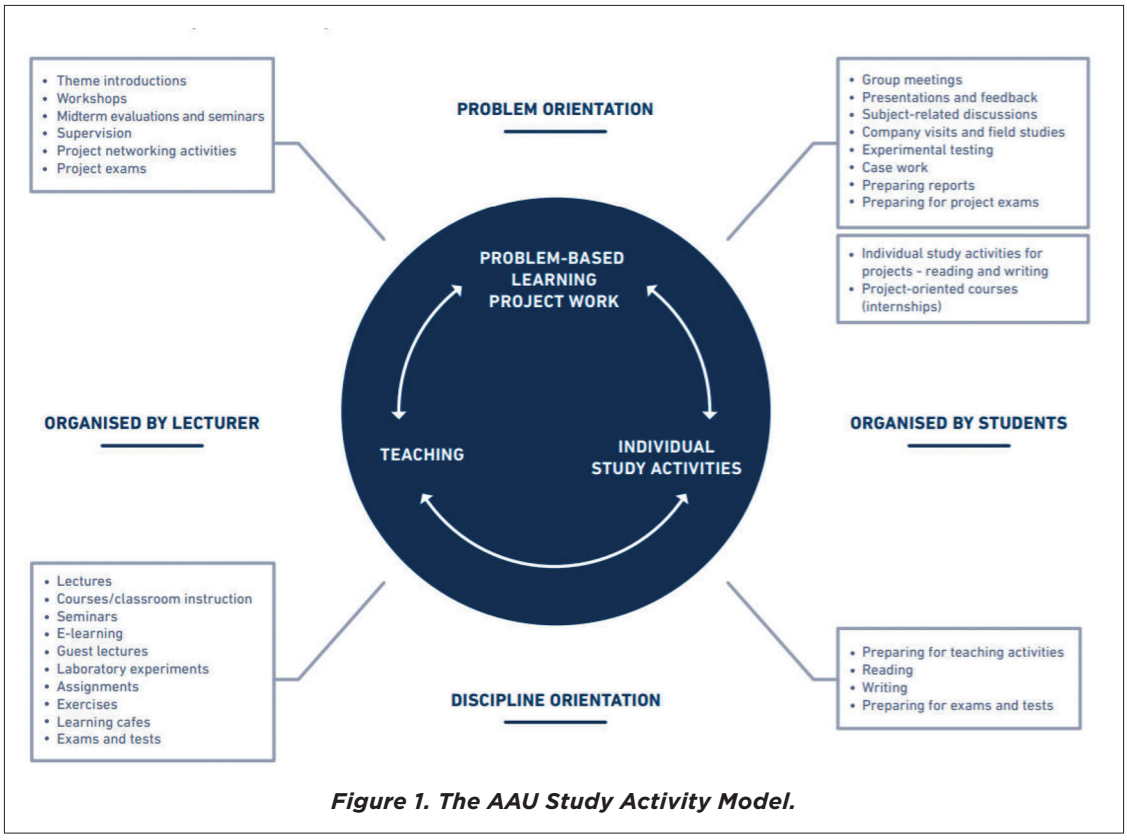

Figure 1. The AAU Study Activity Model.

problems themselves within a thematic framework which covers the formal learning objectives of a particular semester. The organization of projects at semester level differs greatly, from three smaller 10 ECTS modules with mini-projects within one semester, to one 15 ECTS project per semester, to larger interdisciplinary projects involving clusters of student teams working together on the same project challenge through one or more semesters (Kolmos & de Graaff, 2014). Most projects are based on authentic societal problems and sustainability challenges, many of which are proposed by companies or other external stakeholders and organizations. The interaction with companies varies from an information or case-based level, to solving a company-owned problem, to collaborating and even creating partnerships between students and companies (Kolmos & Holgaard, 2017). The aim to facilitate entrepreneurship, creativity and innovation among the students and in collaboration with society have been further strengthened by the establishment of a new AAU Science and Innovation Hub which facilitates activities across all faculties (AAU, 2021).

PBL VISIONS AND REVITALIZATION

In many institutions, economic and disciplinary interests tend to dominate the development of education; often, the pedagogic approach becomes a matter of individual preferences among academic staff rather than an institutional paradigm. This could also have been the case at AAU had there not been a strategic intervention on the part of the executive management some years ago. In the early 2000s AAU's pedagogical hallmark was challenged. The university had expanded significantly; the original ideas behind PBL had begun to evaporate and were, in some areas of the university, replaced by other approaches to teaching and learning as new academic staff joined the university with limited prior knowledge of PBL. Thus, to revitalize PBL and to reinstall a shared vision of PBL throughout the institution, a project was initiated to make explicit and conceptualize the AAU PBL model and to facilitate a process through which a shared set of institutional PBL principles were developed. The literature on PBL was consulted and a considerable number of interviews were conducted among PBL researchers, staff and students at AAU in order to obtain a thorough understanding of the essential components and ideals of PBL in an AAU context. A draft report on the basic principles of PBL was prepared, discussed and revised by local PBL experts before publication. In the end, the organization agreed on the following components as essential for PBL at AAU and thus constituting the guiding principles of learning in all study programs (Aalborg University, 2015):

- The problem is the starting point of the learning process
- Project organization creates the framework for problem-based learning
- Courses support project work

- Cooperation is a driving force in problem-based project work
- The problem-based project work of the groups must be exemplary
- The students are responsible for their own learning achievements

These PBL principles became the first step in revitalizing PBL at AAU. They created a joint vision, a common understanding, and a shared language of PBL throughout the organization, reinforcing the intention of the university to remain true to its origins. They became a strong, cohesive foundation for educational practice at AAU and guided the framing of and direction for the future of PBL at AAU. Shortly after the publication of the PBL principles, a new university strategy was formulated assigning an entire section of the strategy to the development of PBL. The strategy emphasized PBL as the core of all educational activities: i.e., part of the educational framework (vision and values, curriculum and assessment), the educational practice (students, academic staff and external relations) and supported by staff development units emphasizing and integrating research in PBL. In addition, the first measures were taken to digitalize and make IT an integral feature of PBL (Aalborg University, 2016). The university strategy also allocated considerable funding to PBL enforcement initiatives, such as a three-year research project on the future of PBL and a substantial number of local PBL development projects encouraging academic staff to experiment and develop their own PBL practices, which allowed for a systematic introduction to PBL for students and new members of staff.

THE ROLE OF RESEARCH IN PEDAGOGIC INNOVATION AND DIGITAL TRANSFORMATION

PBL research has been an important component in the history and development of AAU as well as for PBL in general. With new and innovative educational practices follows a need for new conceptual understandings of student-centered learning processes, new teacher roles as facilitators and supervisors, and new organization methods for curriculum development. Accrediting institutions and employers also have a significant need of evidence of benefits and effects. PBL research clearly documents effects in areas such as: motivation for learning, retention rates, competence development, and employers' response to PBL graduates (Dochy, Segers, Van den Bossche, & Gijbels, 2003; Strobel & van Barneveld, 2009). Similar studies on active learning, inquiry-based learning, design-based learning and challenge-based learning (Atman et al., 2007; M. Prince, 2004; M. J. Prince & Felder, 2006) indicate that when students are actively involved in decision-making regarding their own learning processes, positive effects are seen in motivation and knowledge retention (Norman & Schmidt, 2000; Strobel & van Barneveld, 2009). At AAU, a recent cohort study on Danish engineering students documents that graduates from AAU find themselves better prepared for the labor market and more engaged in sustainability and societal issues in comparison with students from

other Danish engineering institutions (Kolmos, Holgaard & Clausen, 2021). Furthermore, working with real-life problems provides a better understanding of how work is organized in companies and thus increases employability (Kolmos & Holgaard, 2017; Kolmos & Koretke, 2017).

A systematic problem- and project-based approach to digital transformation is natural at AAU, driven by the needs and goals of the organizational units and their stakeholders and with the PBL principles and study activity model in mind. Thus, researchers, staff, and students are directly involved in the various stages of the digitalization process to ensure that all knowledge, experience, and skills are brought into play throughout the entire process - from identification and analysis of needs to implementation of solutions in the organization. Local, cross-faculty, and institution-wide research- and development projects have been initiated to support digital transformation in current and emerging educational practices, such as flipped semester and life-long learning through flexible continuous education, as well as an institution-wide process of ensuring that digital skills are integrated into curricula and projects in all degree programs. Current initiatives build on the three-year institution-wide research project *PBL Future* launched in 2017 (Aalborg University, 2017), which consisted of five subprojects each developing research-based directions for PBL in a digital age addressing particularly pressing issues, namely: student-centered problem design, emerging collaboration skills for a digital age, strengthening PBL competency development, facilitating individual reflection, and flipped classroom for PBL. These subprojects were supported by a baseline study with the aim of mapping out existing practices and understandings of PBL at AAU from student, staff and curriculum perspectives, and applying scenario methodologies to point to future directions for PBL at AAU. In addition to this, PBL Future addresses questions specifically related to researching PBL as an institutional phenomenon, including how to capture and understand the complexity of PBL in multifaceted (physical and blended) learning spaces as well as how to organize and ensure perspectives from all faculties and research units in institution-wide digital transformation (PBL Future, 2021).

To remain at the forefront of research in PBL and to further facilitate the ongoing transition to digitally supported problem- and project-based learning, AAU has recently initiated the establishment of a new Institute of Advanced Study in PBL (IAS-PBL) to be launched in early 2022 (Aalborg University, 2021). This institute will gather PBL-researchers across AAU and integrate several different research- and development initiatives and units including the Aalborg Centre for Problem-based Learning in Engineering, Science and Sustainability under the Auspices of UNESCO (UCPBL, 2021), the cross-organizational Center for Digitally Supported Learning and AAU's unit for university pedagogy (AAU Learning Lab, 2021). The ultimate goal of IAS-PBL is to ensure the continuation of cutting-edge research in PBL and to contribute to the development and digital transformation of AAU's PBL model, its principles and practices, to continuously innovate and adapt the AAU model to needs and changes within higher education and society as a whole.

FROM SINGLE DISCIPLINE PROJECTS TO INTERDISCIPLINARY MEGAPROJECTS

As part of this transformation, one recent pedagogical innovation and institutional priority is *AAU Megaprojects*. For many years, AAU has practiced various types of interdisciplinary projects, such as the Ecoracer (Team Aalborg Energy, 2021) and the AAU Cubesat Student Satellite (Østergaard et al., 2004). However, the most common project types are still single-group (three to seven students) single-discipline projects, which comprise half the credits for one semester. Since collaboration patterns in society are becoming increasingly varied and complex, AAU aims to offer more variation in project types and collaboration structures to prepare students for their future work life. Thus, in the future, AAU will operate with at least four types of projects with varying degrees of interdisciplinarity and collaboration complexity, i.e. the *discipline project, the interdisciplinary project, multi-projects* and *megaprojects* (see figure 2).

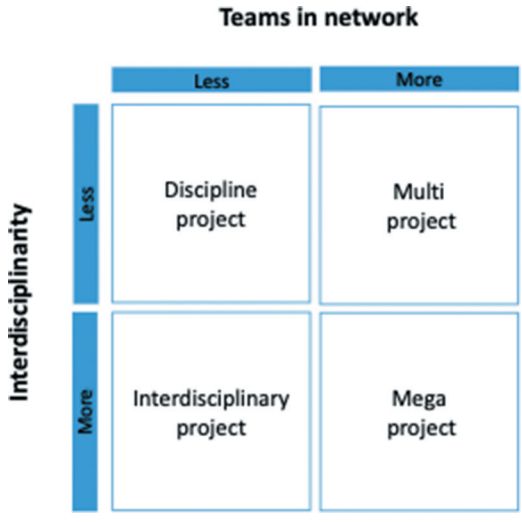

Figure 2. Project variations at AAU.

Whereas both multi- and interdisciplinary projects entail a significant level of cross-disciplinary work, the (educational) megaproject aims to scale up the complexity through a highly ambitious framework project, defined by the following characteristics:

- Addresses one or more of the United Nations' 17 Sustainable Development Goals;
- Interdisciplinary and extending over several semesters;
- Entails a large number of smaller projects, all contributing to solving part of the main issue. The individual projects are typically conducted by groups of students and credited as part of curricula;

- Involves interaction, formative assessment and knowledge-sharing among the participating groups—i.e., cross-departmental/-institutional.
- Students are assigned the coordination and management of the projects.

In the fall of 2019, AAU launched the first such megaproject in collaboration with the Municipality of Aalborg, focusing on the themes '*Simplifying Sustainable Living*' and '*The Circular Region'*, with the theme *'Better Together*' focusing on inclusion and progression in the labour market added in 2020 (AAU Megaprojects, 2021). Each project is developed and refined over time by several participating departments to ensure interdisciplinary collaboration, and AAU is conducting ongoing research to identify potentials and challenges related to the implementation of AAU Megaprojects, from both student-, supervisor- and organizational perspectives (Kolmos et al, 2020; Routhe et al, 2021 and Winther et al., 2020). The purpose of these megaprojects is to facilitate motivation, interdisciplinary and transversal skills, collaborative learning, and entrepreneurship and will eventually be open to collaborations with students and researchers from other universities, as well as external partners such as companies or municipalities through a digital platform. Student projects contributing to the megaproject can be curricular or extracurricular, and students can participate in several sub-projects at different levels, including top-level management, providing the students with opportunities to develop complex project management and leadership skills. It is intended for all future students graduating from AAU to have gained experience from working in different types of project constellations with varying degrees of complexity and interdisciplinarity, and ideally at least one megaproject.

TRACKING PROGRESSION IN PBL COMPETENCES

To ensure ongoing reflection regarding competences obtained through complex collaboration structures, another supporting initiative is the integration of progression in PBL learning outcomes throughout the curricula. At AAU, students are introduced to the AAU PBL Model in the first year and assessed accordingly for their achievements in project management, collaboration and communication, critical thinking and problem identification and analysis (Kolmos, Bøgelund & Spliid, 2019). However, these PBL competences often become tacit knowledge at bachelor and master levels, making it difficult for the students in later semesters to reflect on and conceptualize various project organizations and collaboration patterns, and to make explicit their PBL competences compared with first year students, because reflection on progression has been the individual student's own responsibility. Thus from 2020, across all study regulations, students will be systematically introduced to and assessed on their PBL competences in the first year as well as throughout their

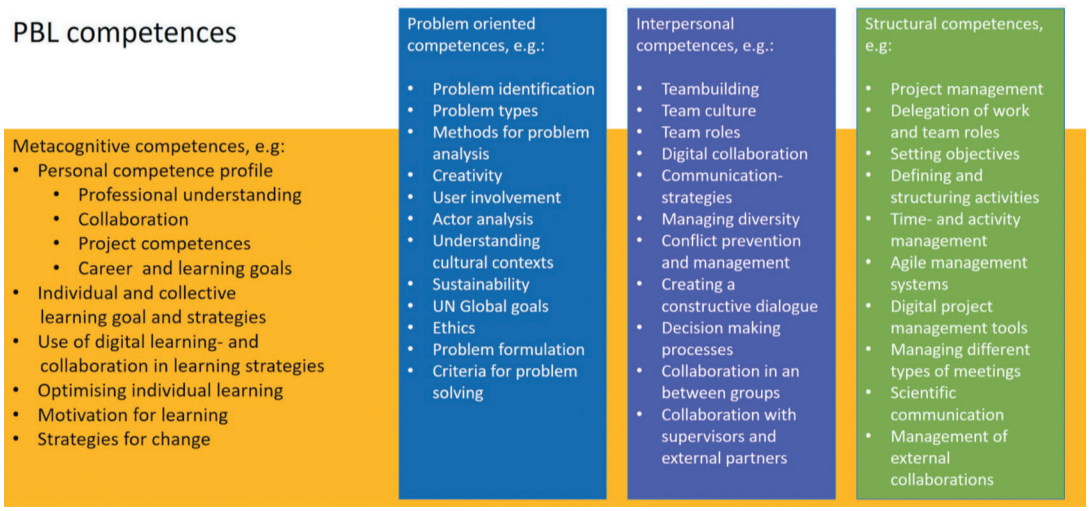

Figure 3. Categories of PBL competences assessed at AAU.

education, based on four categories of competences: *problem-oriented*, *interpersonal*, *structural/leadership*, and *meta-cognitive* competences (PBL Academy, 2020).

As illustrated in Figure 3, meta-cognitive competences are cross-cutting and, through reflection, facilitate the learning of other competences, making students able to analyze, evaluate and synthesize their approaches to learning to access new modes of application. As such, without these cross-cutting meta-cognitive competences, other competences, such as problem-orientation, interpersonal and structural competences, remain at the skill level.

Substantial work has been carried out to conceptualize progression in these four categories of PBL competences and AAU will continue to conduct research and experiment with various ways of facilitating reflection both in terms of comparing different experiences from practice and to further develop its theoretical and conceptual underpinnings (Holgaard & Kolmos, 2019).

NEXT STEPS

Building on these initiatives, and with the establishment of the Institute of Advanced Studies in PBL, AAU will strive to remain at the forefront of PBL-research and engineering education through research-based development and continuous dynamic and transformative collaborations with local and global communities. This naturally includes the integration of new knowledge gained from the sudden and rapid global digital transition in higher education fueled by the covid-19 pandemic, as

well as the implementation of the Sustainable Development Goals both in research and in explicit tracks and learning objectives in the formal curriculum and frameworks for student projects—in particular, in complex and interdisciplinary settings. This, with the aim of ensuring a holistic and systemic approach to problem-solving, which challenges existing paradigms and creates robust and socially responsible solutions and knowledge for a connected and sustainable world.

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