# Transitioning to Project-Based Learning in Data Science Education: An Action Research Study at a Danish Vocational School

Nicolaj Riise Clausen
Aalborg University, Denmark, Nclausen@plan.aau.dk

Søren Hansen
Aalborg University, Denmark, sha@plan.aau.dk

Kim Guldholt
Mercantec, Denmark, kigu@mercantec.dk

Bjarne Poulsen
Mercantec, Denmark, bjpo@plan.aau.dk

Lykke Bertel
Aalborg University, Denmark, lykke@plan.aau.dk

## Abstract

This paper presents an action research study on the transition from a traditional subject-based teaching model to project-based learning (PjBL) in data sciences at a Danish vocational school. The shift was primarily motivated by the need to create a more coherent learning experiences and better alignment between school-based instruction and workplace learning. The new model integrates multiple subject areas into holistic, continuous projects spanning up to ten weeks. Teachers and industry representatives participated as co-researchers to examine (1) the transition process, identifying areas for improvement, and (2) the benefits, challenges, and developmental potential of this new pedagogical model and students were interviewed on many of the same subjects. The study was conducted in three phases: exploratory focus group interviews with students, semi-structured interviews with teachers, and a workshop with teachers and industry stakeholders. Results indicate strong support from both students and staff, with notable improvements in student engagement and perceived relevance of learning. However, challenges related to logistical constraints, teacher adaptation, and balancing student autonomy with necessary instructional guidance were also highlighted. These findings provide valuable insights for other vocational schools considering similar pedagogical transformations and informs the further pedagogical development at the vocational school in question.

***Keywords***: project-based learning, Vocational education, Action research, Curriculum development

# 1 Introduction

The rapid evolution of technology necessitates continuous adaptation in educational practices to ensure students acquire the competencies needed for future employment. At Mercantec, a Danish vocational school, the previous curriculum structure consisted of week-long, single-subject courses with frequent teacher changes. Recognizing issues related to this fragmented structure, the school for data-sciences under Mercantec initiated a transition to project-based learning (PjBL) to foster deeper learning, strengthen relationships, and improve the relevance of educational experiences. Project-based learning at Mercantec involves students engaging in extended projects that integrate multiple subject areas and encourages self-directed learning, collaboration, and critical thinking, which are crucial competencies for modern industries. While PjBL has been widely adopted in higher education fields such as medicine and engineering, its implementation in vocational education remains less studied. Therefore, this practice paper aims to explore the transition process, assess the benefits and challenges encountered, and provide recommendations for optimizing the implementation of PjBL in vocational settings.

## 1.1 Background

In recent decades, Problem-Based Learning (PBL) has gained significant popularity as a pedagogical approach in higher education, particularly within medical and engineering programs. Over time, more variations, especially project-oriented adaptations of PBL have gained traction, not only in engineering education but across a broad range of disciplines (Chen et al., 2021; Leary, 2012; Servant-Miklos, 2019; Walker & Leary, 2009). Although PBL can take many different forms depending on the context in which it is implemented, there are core characteristics that define the approach. In many PBL models, there is a shift away from broad theoretical orientation through traditional courses in favor of a greater focus on specialized and applied knowledge in project work (de Graaff & Kolmos, 2003). Such a transition often means that students do not cover as extensive a theoretical foundation as in more traditional teaching models, where theoretical courses constitute a larger part of the curriculum. To compensate for this, PBL places great emphasis on developing students' ability to work independently and autonomously so that, both during their education and in their later careers, they are better equipped to identify and seek out the knowledge they need to solve given problems (Clausen, 2023). Self-direction and self-regulation are therefore both outcomes of and prerequisites for PBL as a teaching method (de Graaff & Kolmos, 2003; Ge & Chua, 2019).

Studies have shown that PBL students become better at using information-seeking strategies, setting learning goals, and developing a stronger belief in their own learning abilities (self-efficacy) compared to students from more conventional learning environments (Evensen, 2000). They have also been found to achieve better "library skills" and generally adopt a more proactive approach to literature searching, moving beyond the readings assigned by their instructors and seeking out alternative sources of information (Blumberg, 2000; Blumberg & Michael, 1992; Blumberg & Sparks, 1999; Loyens et al., 2008). Furthermore, research has shown that PBL students are often more self-driven and less dependent on instructor guidance, which supports their ability to work autonomously both during their studies and in their future careers (Clausen, 2021; Dolmans & Schmidt, 2000; Kivela & Kivela, 2005). At the same time, studies indicate that, compared to similar students in other programs, PBL students perceive themselves as better prepared in terms of generic and contextual competencies such as collaboration, problem-solving, and reflective thinking (Kolmos et al., 2021).

## 1.2 PBL in Vocational Education

In vocational education and training (VET), findings from previous studies indicate that implementing project-based learning (PBL) can have a positive effect on students' development of key competencies. PBL appears to be particularly effective in strengthening VET students' critical thinking, problem-solving skills, communication, collaboration abilities, and creativity—competencies that are also highlighted as essential in the 21st-century labor market (Geisinger, 2016; Megayanti et al., 2020). Other studies have shown that PBL can increase VET students' motivation, as they take on a more active role in their educational journey through

project work (Bagheri et al., 2013). Additionally, research has demonstrated that PBL in VET strengthens the connection between theory and practice (Chiang & Lee, 2016), that students working with contextualized problems are motivated to develop original and innovative solutions (Fitri Rahmawati et al., 2018), and that it improves students' communication and collaboration skills, as they continuously explain their work processes, discuss solutions, and present results, becoming better as asking questions, analyzing information and making well-founded decisions (Sasson et al., 2018).

However, research also highlights several challenges associated with implementing PBL in VET. For instance, a successful implementation of PBL in VET requires adequate resources, access to relevant technologies, and a learning environment that supports independent work and collaboration (Liu, 2018). Furthermore, instructors are required to have a deep understanding of the learning process and be capable of guiding students through the complexities of working with problems (Pinho-Lopes & Macedo, 2014). Thus, to enhance the chances for a successful implementation of PBL in VET, challenges such as the altered role of the instructor and the framework for project work must be continuously developed (Megayanti et al., 2020).

# 2 Methodology

With this in mind, the study employed an action research framework to examine the transition to PjBL with different phases, including a pre-planning and design phase, a piloting phase, and a formative evaluation and future directions phase. In this paper we present results from the formative evaluation and future directions phase. The research design in this phase included three data sources:

*Student Focus Groups*: Students participated in 5 semi-structured focus group interviews to share their experiences with both the traditional and PjBL models. Discussions focused on perceived benefits, challenges, and their overall experiences with the new model.

*Teacher Interviews*: Six teachers were interviewed using a semi-structured format. Initial interviews took an inductive approach, identifying emerging themes related to instructional challenges, knowledge-sharing needs, and adaptation to the new model but also implemented findings from the student interviews.

*Industry Workshop:* A workshop was held with teaching staff and industry stakeholders to explore strategies for improving collaboration between schools and workplace internships. Discussions included the alignment of school projects with industry needs and mechanisms for strengthening communication.

To analyze the interview data, a thematic analysis was conducted, inspired by the six phases outlined by Braun and Clarke (2006), in this case adapted to three distinct phases. The purpose of the thematic analysis is to identify, analyze, and present patterns and themes that represent significant aspects of the participants' narratives, without seeking to quantify the occurrence of a given theme (Braun & Clarke, 2006; Patton, 1990). The inductive and constructivist approach emphasizes that the data is not treated in an epistemological vacuum but is analyzed and interpreted in relation to the context in which it was produced (Braun & Clarke, 2006; Galletta & Cross, 2013). Each analytical process following the interviews was structured into the following three phases:

*Phase 1: Coding and identifying themes*

The data analysis began with listening to all interviews and reviewing all notes taken during the interviews, where notes and preliminary reflections on patterns and themes were recorded and revised. This process enabled the identification of recurring topics and statements that could form the basis for subsequent coding.

In this phase, key statements from the interviews were coded and categorized into smaller units of meaning. The coding was carried out with a focus on analytical relevance rather than frequency, ensuring the complexity of the participants' statements was preserved. Additionally, preliminary connections between different codes were noted and tentative overarching themes were produced, based on the relationships

between students' statements, aiming to capture the central experiences and challenges described in relation to the new teaching model.

*Phase 2: Review and validation*

In this phase, themes were evaluated in terms of their coverage of the data material. First, they were compared with the original interview excerpts to ensure they remained faithful to the participants' experiences. Subsequently, all interviews and interview notes were reassessed to examine whether the identified themes adequately represented the participants' statements or adjustments were needed.

The final themes were formulated and described based on their analytical contribution to understanding the study's research aims. Throughout this process, emphasis was placed on clarifying how each theme related to the students' experiences.

*Phase 3: Reporting of results*

In the reporting, themes were selected to create a coherent and nuanced representation of students' and staff members' experiences while preserving an understanding of their practices and context. Based on the inductive approach, a central goal was to ensure that the participants' voices were clearly represented in the presentation of results.

# 3 Findings and Discussion

*Student Perspectives*

Students generally expressed strong support for the new model, citing several key benefits. One of the most frequently mentioned advantages was the continuity of having a consistent instructor throughout the up to ten-week long periods, which helped foster stronger student-teacher relationships and ensured more personalized feedback due to enhanced insights of the teachers into the individual students. Additionally, students appreciated the real-world relevance of project work, as it provided a clearer link between theoretical concepts and practical applications and simulated their apprenticeship test which the students in general were quite concerned about being ready for.

However, challenges were also identified. Some students struggled with the increased emphasis on written documentation, particularly those who were more accustomed to practical, hands-on learning. Additionally, logistical constraints, such as hardware access for extended projects, were raised as concerns. Despite these difficulties, most students felt that the new model better prepared them for their final assessments and future employment.

*Teacher Perspectives*

Teachers also largely endorsed the transition to the new model, recognizing its potential to enhance student engagement and learning outcomes, although they faced significant challenges in adapting to their new roles. One of the primary difficulties was the lack of structured onboarding, leaving some educators feeling unprepared to navigate the new system. Several teachers described the transition as "laying the tracks while the train is moving" highlighting the difficulty of implementing the new model while actively teaching, although they also recognized that it was difficult to implement the model in any other way.

Another challenge was balancing student autonomy with structured guidance. Some educators developed strategies such as "minimum viable project templates" to provide students who wanted it with a baseline structure while other students were encouraged to be more self-directed if they felt up to the challenge. Additionally, the autonomous nature student projects in the new model required teachers to broaden their expertise beyond their traditional subject areas, underscoring the need for ongoing professional development.

*Industry and teacher workshop*

A key outcome of the industry workshop was the recognition that stronger collaboration between schools and companies is essential for the success of the new model as well as to ensure that school-based learning aligns more closely with industry expectations, improving student preparedness for the workforce.

Participants proposed several initiatives to enhance integration, including: 1) Increasing direct communication between teachers and industry mentors, 2) Developing structured feedback mechanisms where industry representatives provide input on student projects, 3) Facilitating guest lectures and industry visits to expose students to real-world challenges.

Based on ideas from the workshop, scenarios for possible collaborations between schools and companies was developed. For instance, in one scenario, the teacher would organize a guest presentation from a relevant internship company. The purpose of the scenarios was to crystalize ideas into concrete actions that could improve the collaboration with the company. In addition, scenarios could be used as a a way to pass on experiences from previous to future teachers and perhaps even to other schools.

As part of the future directions phase, the results from interviews and initiatives from the workshop are discussed regularly in weekly follow-up pedagogical staff meetings. In these meetings, various current didactic topics and issues are discussed in the teaching group, including internship collaboration.

# 4 Future work

The transition to PjBL at Mercantec represents a significant pedagogical shift, bringing both advantages and challenges. Students and teachers generally view the model favourably, acknowledging its potential to enhance learning, student-teacher relations and real-world applicability. However, the success of this transition could be improved by focusing on sustained professional development, structured onboarding, logistical planning, and stronger collaboration between educational institutions and industry partners. At Mercantec they, to some degree, already started this work. One finding from interviewing teachers is that the classroom teacher role previously has been too demanding. To accommodate this, teachers now work in teams of 3 sharing two classes. The idea is that, besides reducing the workload for each teacher, the third teacher in this team is meant for new teachers being onboarded by two colleagues. Besides, weekly meetings among teachers are assigned for sharing and discussing subjects like lesson plans and classroom management. In addition to these changes, the following actions could be considered. Training sessions and professional development workshops can help teachers adapt to their evolving roles, shifting from traditional instruction to guiding student-driven learning.

The school prioritise building stronger relations, both among students and between students, teachers and companies. To accommodate this a student's advisory board together with an online communication platform has been developed. Another recommendation is strengthening industry partnerships by increasing direct communication between teachers and industry mentors, facilitating guest lectures, and implementing structured feedback mechanisms will better align school-based learning with workplace expectations. To meet this an Mercantec so far established an education committee with representatives from companies to ensure practice anchoring of student's projects has been launched.

Lastly, continuous assessment and refinement of the new model will be essential. Regular evaluations incorporating student, teacher, and industry feedback are already ongoing and will help identify areas for improvement and ensure that the model remains responsive to both educational and industry needs.

By taking these findings into account, Mercantec can create a more sustainable and effective PjBL framework, fostering deeper student engagement, better student-teacher relations, stronger educator collaboration, and improved alignment with industry demands. The lessons learned already spreads both internally to other departments at Mercantec and potentially also external to other schools as visits to learn from Mercantec has already been planned.

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