Aalborg University, Denmark
Case Study Part B – Institutional context

Undergraduate engineering student intake (1st year cohort 2020/21):	≈ 2000
Number of engineering faculty:	≈ 770
Duration of undergraduate engineering degree (to BEng):	3 years

1. Defining features of Aalborg's engineering education

Since its foundation in 1974, Aalborg University has taken a distinctive problem-based learning (PBL) approach to its research and education activities. Half of the undergraduate curriculum is devoted to group projects that each span a full semester, with the remaining half devoted to disciplinary-based 'taught courses'. The group projects are underpinned by a student-led and team-based pedagogy: supported by facilitators, students are expected to identify and define their problem, as well as manage and source the materials needed to deliver their project. Within the university's two Faculties of engineering and technology[1], most project groups are allocated a dedicated meeting room on campus for the duration of the semester where they are able to meet team mates and work on their project. The university's undergraduate PBL model is supported by the in-house UNESCO PBL Centre[2], whose research and ideas also have considerable impact across the wider engineering education sector.

In 2018, Aalborg's Faculties of engineering and technology[1] embarked on a major programme to reimagine their PBL pedagogy. In the context of a two-decade increase in student numbers, the vision is to set a new benchmark for engineering PBL that could operate at scale and equip graduates to tackle the complex interdisciplinary challenges facing society. The model combines a student-led, interdisciplinary and flexible approach with scaffolding that allows students to progressively build, practice and strengthen what are termed *PBL Competencies*[3] throughout their studies.

The implementation of the new PBL vision began in 2018 and many components were in early development or piloting when the university pivoted to online teaching in March 2020. Three inter-related threads are central to the reform, as outlined below, relating in turn to project variation, the nurturing of student competencies and digitisation of learning materials.

The **first thread** is to embed a progression in the complexity and interdisciplinarity of projects tackled by students throughout their studies. In the words of one interviewee, it aims to ensure that "*students do not get stuck in a rut of working on the same types of projects in the same way*" but instead experience

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[1] The Technical Faculty of IT and Design; and the Faculty of Engineering and Science

[2] Aalborg Centre for PBL in Engineering Science and Sustainability under the Auspices of UNESCO: https://www.ucpbl.net

[3] The PBL Competencies are divided into four interrelated categories: **problem-oriented competencies** (relating to students' ability to identify, analyse, formulate and solve authentic problems); **interpersonal competencies** (relating to students' ability to collaborate in problem-based work, including relationships internal and external to the group); **structural competencies** (relating to students ability to organise and manage problem- and project-based work); and **metacognitive (or reflective) competencies** (relating to students' ability to reflect professionally on the learning process itself).

variety in both the construction of the project and complexity of the problem as their learning progresses. This might include, for example, variation in the projct duration, disciplinary scope, and structure of inter-team collaboration. This step-by-step progression builds from the first year of study and culminates with an option to engage in the newly-established MegaProjects[4] in the final semesters of study. Framed around one or more of the UN's Sustainable Development Goals, MegaProjects challenge students to address authentic multi-factored, interdisciplinary problems as part of a network of inter-connected teams drawn from across the university. While facilitated by an interdisciplinary faculty group, each MegaProject is coordinated and managed by the students themselves.

The **second thread** is to ensure that students are equipped to conceptualise, reflect upon and showcase the competencies developed as part of their problem-led education. Prior to the launch of the new PBL vision, all incoming engineering students were already participating in an introductory PBL course in their first semester of study to support the formation of their PBL Competencies[2] in areas such as collaboration, project management, and problem understanding. However, advancement of these capabilities beyond this point was understood to be largely tacit, with no formal mechanism to reflect upon or assess them at an individual student (rather than a group) level. As a result, some students were left struggling to conceptualise and articulate their relevant experiences and strengths to prospective employers and peers on graduation. To address this challenge, from the spring of 2021, all engineering students at the university are required to build a 'PBL Competency Profile'. At the completion of their studies, each students' PBL Competency Profile will provide a self-reflective analysis of their experiences, achievements and strengths; this portfolio, and the quality of self-analysis it contains, will be assessed via an individual oral exam. Throughout their studies, students' profile development will be guided by structured self- and peer-reflection sessions. In addition, each Faculty will identify priority competencies – such as conflict resolution or collaborating with external partners – whose development will be advanced through dedicated workshops embedded into the curriculum.

The **third thread** is to establish a digital learning infrastructure that facilitates flexible, student-led learning and problem-solving. This new infrastructure will help to support the remote team-working, communication, and project management that lie at the heart of the university's growing number of complex and interdisciplinary group projects. However, the major focus for these digital tools is to reshape the university's taught courses. Inspired by global best practices, the vision is to offer students the flexibility to access the information and learning resources needed to advance their group projects, as and when they need it. This thread of asynchronous digital material (offered as both core and elective modules) will be embedded within the taught courses, complementing the synchronous materials offered in blended and face-to-face modes. PBL Digital is one major initiative driving these reforms across the engineering disciplines. One of its early areas of focus is to support faculty to identify the best modality for delivery of each core component of their courses, be that via face-to-face, remote or blended learning.

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[4] Aalborg University MegaProjects: https://www.megaprojects.aau.dk

2. Aalborg's experience of emergency teaching in engineering

2.1. Emergency teaching restrictions

Aalborg University pivoted all undergraduate programmes into a fully online mode in March 2020, a few weeks into their spring semester, with only the end-of-year examinations subsequently delivered in person. Since September 2020, the university's education has oscillated between a blended mode – where most classes were delivered online but students were often able to connect face-to-face in their project rooms – and a fully online mode. At the time of writing, in February 2021, the university had launched its spring semester fully online.

2.2. Managing the transition to emergency teaching

The university's initial online pivot in March 2020 was rapid. The lockdown came into effect within two hours of the Danish government's announcement, which left little time to make preparations or retrieve equipment from campus. The primary focus for the university at this time was simply the practicalities of translating its PBL curriculum online.

One distinctive feature of Aalborg's pedagogy is the range of modalities and interactions it supports: as well as components organised by instructors (such as workshops, lectures and end-of-semester oral exams for group projects), it embeds a significant number of components organised by students, particularly with respect to managing and progressing their groups project. While undoubtedly supported by the PBL Digital initiative, the logistics for transferring this complex range of learning modes into an online format was challenging and resource-intensive. As one engineering Pro-Dean noted: "*so much of our education is student-led, there are fewer one-size-fits-all courses and elements that can be transferred online than you would find in other universities*". This complexity is particularly apparent in the 50% of the curriculum dedicated to group projects. So, for example, in many universities worldwide, the experiments undertaken during 'engineering labs' are predetermined by instructors, with each groups' findings focused on a similar outcome and recorded in a similar form. In contrast, at Aalborg University, engineering labs are often used as a mechanism for students to advance their group projects, and therefore the goals and focus on any experimentation is determined by the group in question, with on-demand facilitation provided by technicians.

Despite these challenges, interviewees went on to note, with some surprise, that students' transition from face-to-face to online learning, particularly in the 'group project' half of the curriculum, was "*relatively painless*". They largely attributed this resilience to the students' training in PBL and experience of directing their own learning and self-managing their work. In the words of one university leader: *"PBL gives you two things: it's a pedagogical model for how you engage in problems, but it is also a very nice way to structure the student's working life... it gives the students a schedule... they were not waiting for the teachers to deal with [the impact of COVID-19]; they are used to taking their own responsibility"*. This familiarity with self-directed group learning, however, was less apparent amongst one particular

student population: the new cohort that started their studies in September 2020. Unlike those that pivoted online in March 2020, these students only had a few months' experience of PBL training and face-to-face problem-solving before the university again shifted into a fully online mode in December 2020. They also lacked the connectivity with peers beyond the groups formed for their first semester project, and therefore were less likely to benefit from broader student support networks.

At the time of writing, in February 2021, Aalborg University was entering its third semester of emergency teaching. It was noted by interviewees that, while faculty and students alike were "*exhausted, spending hour after hour at the computer*", each semester had heralded improvements and refinements to the university's online or blended approach. However, the university had undoubtedly benefited from the face-to-face start to its first two semesters of emergency teaching. The university's student-led process of team formation for group projects, as well as early bonding and expectation setting within these groups, had all been undertaken in this face-to-face period. At the time of writing, faculty were anticipating with some trepidation the impact of a fully online start to group projects, where team formation, orientation and bonding would all be undertaken remotely and students' interactions would not build upon an existing face-to-face relationship.

2.3. Addressing the challenges of emergency teaching

When reflecting on the challenges faced during 'emergency teaching', interviewees consistently spoke about the pivotal role that has historically been played by both the physical facilities and the face-to-face interaction of staff and students in the university's PBL approach. The dedicated project room allocated to each engineering student group was characterised as "*a personal space, a second home*" on campus which anchored students' shared learning experience. Students would typically spend much of their working day in this space, outside scheduled classes. Group learning and staff/student interaction in these spaces was also understood to be underpinned by tacit knowledge: "*through interacting, body language, eye contact*", which often guided the type and levels of facilitation offered by instructors.

With the reduction or removal of students' access to project meeting spaces, the pivot to emergency teaching was understood to "*put a lot more pressure*" on group project work. It precipitated a formalisation of some student-to-student and student-to-instructor interactions, which took place through pre-arranged meetings, rather than drop-in sessions or "*seeing someone in the corridor*". This issue was exacerbated by the increasing tendency of students to connect without web-cams switched on, such that peers and facilitators were unable to see their faces. Interviewees noted a number of consequences of this shift in students' modes of interaction. Some pointed to "*more conflicts than normal in groups... [where] students have a difficult time 'sensing' each other and being open about the challenge they have*". Others noted that, rather than working synchronously together, students often broke project tasks into discrete elements to be undertaken by individual students alone, and then "*assembled the project at the end, more like the approach they would have used at [high] school*".

Since the introduction of emergency teaching in March 2020, faculty and facilitators have employed a number of techniques to address these challenges. For example, some shifted group facilitation from

a discrete activity (providing support during scheduled classes or sessions) to a continuous activity, "*as a constant presence*", 'checking in' on students regularly. It was also noted that the increasing use of instant messaging platforms, such as Discord, has supported peer-learning and the dissemination of information between students. Through these open 'chat' platforms, facilitators' feedback and responses to questions from one group can now be accessed by the entire cohort. As one interviewee noted, "*there was always a lot of repetition in the questions and answers which was not shared across groups... [now] channels are open. There is more openness in the way we share*".

The online pivot has also brought into sharp focus the major role played by students' informal, non-scheduled peer interactions to their learning and development. One interviewee described these as "*the informal chit-chat before the lecture or [walking] between buildings... interactions that create a community where they are learning together*". Prior to emergency teaching, such interactions were serendipitous and emerged as a natural consequence of students' shared learning spaces on campus. A major impact of online learning was the significant drop in such interactions, a loss that was felt deeply by many students. Reconstructing such serendipitous and informal interactions online is one of a number of research themes in digital PBL being advanced at Aalborg University.

3. Impact of emergency teaching on educational approach

Interview feedback made clear that, while the experience of emergency teaching is unlikely to change the direction of travel for engineering education at Aalborg University, it has undoubtedly advanced and accelerated many aspects of its new PBL vision launched immediately prior to the pandemic. As discussed below, this acceleration was seen to impact two areas in particular: faculty pedagogical culture and the 'stress testing' of key innovations.

The **first impact** of emergency teaching, as noted by interviewees, has been on faculty culture: on their attitudes to both pedagogical change and digital learning. Historically, much of the innovation and pedagogical research at Aalborg University has focused on the 'group project' half of the curriculum, which has been central to its leading profile in engineering education globally. While many innovative practices were apparent in the 'taught courses' half of the curriculum, there remained a heavy reliance on teaching-centred and lecture-based delivery. Given the impact and profile of the university's education overall, the case for systemic change to 'taught courses' did not always resonate with faculty, with many reluctant to dedicate time to converting courses into asynchronous learning materials.

As with many universities across the world, the pivot to emergency teaching required all Aalborg University faculty to convert their courses to an online delivery mode. Interviewee feedback suggested that the most far-reaching pedagogical shift triggered by this pivot occurred not amongst the existing educational 'pioneers' but amongst other faculty groups that had historically taken a more teacher-centred approach, particularly within the 'taught courses'. Amongst this group, the rapid shift online was understood to have precipitated "*a breakdown of the barriers for faculty's first encounter with*

designing and delivering online learning components". As a result, it had significantly accelerated many of the changes planned under the PBL Digital initiative. Interviewees also pointed to a recognition amongst many in this group that online delivery laid bare some of the weaknesses of a teacher-centred approach: "*you cannot lecture for 45 minutes... sitting and talking into a screen for 45 minutes online is awful, you need to have more interaction*". In response, a core group of faculty started to adopt new approaches to activate and engage students, breaking up classes using interactive and peer learning, often in break-out sessions.

While the rapid changes made to accommodate emergency teaching in March 2020 may only have been considered a temporary solution, interviewee feedback suggested that, after three full semesters of emergency teaching (at the time of writing), many of the changes made to enable blended and student-centred learning in the 'taught courses' are likely to be retained permanently. This is understood to have accelerated the university's plans to establish a much closer alignment between 'taught courses' and projects, whereby students are able to access asynchronous digital materials as and when needed to help them address challenges or new ideas in their group projects. Nonetheless, it was also acknowledged that some of the digital material developed in 2020 "*was a digital replication of what was [previously] developed in analogue"* and therefore considerable revision and development will be needed through the PBL Digital initiative to improve their quality and impact for future use. Despite this challenge, interviewees concluded that a new emphasis on digital learning was here to stay. In the words of one, "*we are never going back face-to-face. We were not there before [at Aalborg], but it will go more so, more balanced, more blended*".

The **second impact** of emergency teaching, as suggested by interview feedback, has been the opportunity to 'stress test' a number of components of the university's new PBL vision. Many of these pilots and advancements rest on the university's growing digital learning infrastructure and parallel research undertaken by the UNESCO PBL Centre. For example, emergency teaching has turned a spotlight on the potential offered by remote collaboration and online project management for the suite of the university's new complex group projects. Indeed, since March 2020, three MegaProjects have been supported, managed and delivered almost entirely online. Interviewee feedback also suggested that the rapid development of digital materials is also paving the way for other advancements at the university, such as micro-credentialing and the development of MOOCs for external audiences.

Emergency teaching also showcased the significant potential for projects that connect students and external collaborators from across the world. In the words of one interviewee, "*the idea of having students not physically in the country for a course is now a possibility in a way that it was not 6 months ago*". What has proved critical to the engagement of a geographically dispersed community has been the flexibility offered by the university in the ways in which projects are developed and delivered: flexibility, for example, in the scheduling and course credit allocation for projects or in the sequencing of learning objectives. Interviewee feedback suggested that such ongoing flexibility from university managers will play a central role in facilitating future bottom-up faculty innovations, beyond the current period of emergency teaching.

Source of evidence

The case study for Aalborg University (including Part A, the review of the Giraf project, and Part B, this review of the 'institutional context') drew upon one-to-one interviews with 13 individuals: the Vice-Dean of Education in the Technical Faculty of IT and Design; the Vice-Dean of Education in the Faculty of Engineering and Science; one department head; two research leaders from the UNESCO PBL Centre; three undergraduate students; one external collaborator from a specialist school working with the Giraf project; one project coordinator; and three engineering faculty. The interviews were conducted between November 2020 and February 2021.

Further information about the methodology for development of CEEDA case studies is given at the project website[5].

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[5] CEEDA case study structure and approach: https://www.ceeda.org/about#case-studies