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Exploring students' reflections of teamwork competences in PBL

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BY
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AALBORG UNIVERSITY
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CV

My name is Anders Melbye Boelt and I am a PhD fellow at the Aalborg Centre for Problem Based Learning in Engineering Science and Sustainability under the auspices of UNESCO (UCPBL) as well as a teaching assistant at the Department of Culture and Learning at Aalborg University (AAU). I completed a master's in IT, Learning and Organizational Change from AAU in 2017 and worked as a research assistant prior to my employment as a PhD student at the UCPBL at the Department of Planning. During both employments I was part of the cross-faculty research project PBL Future, where I participated in two distinct subprojects: one concerning improving students' individual reflective practice of competence development using different types of digital technologies, and as part of a baseline study researching the integration of PBL competences into formal curricula. My PhD project draws on experiences from PBL Future and also has a focus on generic competence development.

FOREWORD

When I finished high school, my father suggested that I pursue a career in engineering; naturally, like any obstinate adolescent in their formative years, I did not follow his advice. Fortunately, my father has learned a lot since – although it may have taken longer than seven years. Growing up, the phrase *ka' det nu os' pas'?* (which roughly translates into *can that be right?* or *is it really so?*) was integral when at first glance something appeared to be too good to be true. Reflecting on it now as a parent and researcher, I will qualify our inquiries as a kind of Deweyan consummation of an experience of *some thing* or units (Dewey, 2005, 2008), but I am not sure if my parents would lend credence to my academisation of my brothers' and my upbringing. Still, performing such reflective practicums provided new perspectives to occupations and in time became habitual and very much a part of who I am. Consequently, I ask *ka' det nu os' pas'?* of perhaps too many things, and also to my writings and work. In his introduction to a collection of early essays, Bernstein (1973) notes that he too writes slowly, and I find solace in the fact that even accomplished scholars at times struggle too. But as Steen Nepper Larsen noted during at a PhD course at AU, one can indeed learn to write, and even learn to enjoy the process as well. I have been looking forward to writing this supporting text.

I have always been fond of authors who emphasise their personal motivation for a particular subject. I consider it akin to limited bracketing or framing, being 'honest and vigilant of her own perspectives, pre-existing thoughts and beliefs' (Tufford & Newman, 2012). This is not limited to the 'isolated' process of writing the thesis but has been a continued practice throughout the entire process, where I at times struggled to suspend my preconceptions of concepts used and current trajectories of higher education in general. A critical reading of this thesis can prompt questions as to whether students' perspectives on their competence development is more important than formal accreditation frameworks based on professional practice. This is not the agenda. Rather, I propose that students' perspectives gain a more prominent place in curriculum reforms, acting as supporting interlocutors – particularly in pedagogical, or, perhaps more fitting, andragogical approaches emphasising various degrees of student-centeredness, or as denoted in the early iterations of PBL, participant-direction (Illeris, 1978, 1981). As interlocutors, students have previously contributed to clarify misconceptions and differences of interpretive frameworks between staff and students concerning curriculum design in processes not limited to questionnaires or measurements of course satisfaction (see for instance Brooman et al., 2015 and Seale, 2010). From a naïve-idealistic point of view, participating in debates of higher order questions such as what "*kinds of human development are being promoted through a curriculum*?" (Barnett & Coate, 2005, p. 26), students may become aware of who and not only what they wish to become.

Lastly, completing a PhD project on students' competence development has motivated me to reflect more on my own competence development, which in turn has made me

sympathise with the students. Throughout my education I have done almost exactly what I wanted to within the given themes, gravitating towards what brings me most enjoyment and less what is expected – and dare I say, never once investigated formal regulations or intended learning outcomes. Hence, clarifying competences hitherto habitual and tacit is not an easy task, I think. I can tell what I enjoy doing, and although 'being competent' is also often associated with an enjoyment of being engaged in a specific activity (Raven, 2001), I am still unsure if 'competent' is the correct classification – competent compared to who and what? But as my co-supervisor has said, a finished PhD is not the final stop, and hopefully I will get there eventually. In this sense, although the thesis is indeed a consummation of three years of work it is "*not a separate and independent thing; it is the consummation of a movement*" (Dewey, 2005, p. 39).

I participated in a PhD course were a lecturer presented parts of his PhD project and emphasised an approach which he called 'A Hero's Journey'. Although I do not find myself using that epitaph, the notion still prompted me to consider various stylistic approaches. An early idea was that of a crime novel, where a culprit, here a research question, was under investigation involving a variety of witnesses. It would probably be fun to write, but given my experiences in dramaturgy, not so much to read. Still, with the image of a hero's journey, I will present and experience my included articles, anew. I shall act at my own peril, and experience them again:

> *In other words, all experienced objects have a double status. They are individualized, consummatory, whether in the way of enjoyment or of suffering. They are also involved in a continuity of interactions and changes, and hence are causes and potential means of later experiences. Because of this dual capacity, they are problematic.* (Dewey, 2008, p. 188)

Interacting with the articles again then eradicates the (*my*) idea of characterising them as final, thus stimulating an unsentimental consummation of them yet again, marking the articles as uncertain objects in a new transaction and experience.

ENGLISH SUMMARY

Societal complexity and interdisciplinary accountability have amplified the need for competences reaching across professional engineering practice and disciplinary boundaries, also known as generic competences. To this end, educational institutions are pivotal in developing the individual engineering student's generic competences. Some research suggests a stronger institutional emphasis on professional identity development, where others highlight generic competence development as a potential route. The research presented in this thesis focuses on the latter, together with how generic and problem-based learning (PBL) competences are conceptualised from a formalised and institutionalised perspective as intended outcomes, and how these correspond to students' articulations of their experiences in a PBL curriculum.

Several pedagogical models emphasise generic competences across various levels of curriculum making, integrating them into the intended and enacted curriculum. PBL and *Conceive, Design, Implement, Operate* (CDIO) are examples of such approaches, both emphasising authentic problems and team-based project work as central principles for learning activities. During project work, students can potentially develop a wide variety of generic competences in such domains as collaborative problem-solving, teamwork and project management. However, there is a risk that such generic competences turn tacit over time as project work becomes increasingly informal and habitual. To aide engineering students' attention and reflection of generic competences, different approaches are applied, such as explicit learning outcomes, pedagogical and scaffolded activities promoting reflection or pedagogical interventions catering to the development of generic competences. However, these are often based on mature experiences and students' contributions to approaches outlined above are mostly absent. To this end, this thesis not only address students' perceptions and experiences of generic competence development, but also how these can contribute to the development of formalised learning outcomes.

This thesis draws inspiration from curriculum theory and levels of curriculum interpretation and explores generic competences from different perspectives: a broader view of engineering students' perceptions of generic competence development across PBL practices; situated perspectives concerning the intended and interpreted curriculum using Aalborg University (AAU) as a critical case of systemic integrated PBL.

The research presented in this thesis is based on three articles: a literature review synthesising existing empirical data and methods concerning engineering students' perceptions of generic competence development in PBL; a theoretically informed content analysis of 10 bachelor's programmes' formal curricula from AAU; and a thematic analysis of 130 engineering students' PBL competences profiles, likewise from AAU master programmes.

Article I present a literature review of empirical data concerning engineering students' perceptions of generic competence development in PBL. Furthermore, the review

identifies what generic competences are emphasised in the included literature as well as how these are elaborated and expanded as concepts. The review points to several challenges when addressing competences, primarily that the included competences are poorly defined and only superficially described. It is recommended to carefully unpack selected generic competences in constituting parts for a more detailed analysis and understanding of engineering students' generic competence development.

In article II I present a content analysis of 10 formal curricula to explore the prevalence of statements regarding generic competences in formal curricula from AAU. The analysis shows that the bulk of explicit learning outcomes related to generic competences is found within the first year of study, and for most educational programmes related to an introductory course outlining the study practice of AAU. The following semesters' learning outcomes related to PBL become more sporadic, and often similar formulations are used across semesters and educational programmes. In the article it is discussed whether the scarce prevalence of learning outcomes related to PBL can potentially render students' PBL practice and subsequent generic and PBL competence development tacit.

Article III is based on the findings from article I, and addresses engineering students' experiences of teamwork competences in a systemic integrated PBL at AAU, as well as how these can be used in curriculum development. A thematic analysis of 130 students' PBL competence profiles resulted in the construction of five themes: finding complementary competences; establishing teamwork culture; preventing and managing conflicts; awareness of self and others; and shared situational awareness. The article concludes that students develop a sensitivity to team members and malleable positions in teams during project work and that they can maintain flexibility in their teams to accommodate unidentified and emerging challenges in the internal or external environment affecting teamwork.

The different perspectives on generic and PBL competence generally paints a favourable picture of PBL in supporting students' generic and PBL competence development across modes of PBL practices. While learning outcomes related to generic teamwork competences are general, students' articulation shows a variety of themes and detailed descriptions of generic competences and subcomponents embedded in teamwork. The results of these indicate that including students' experiences can provide a richer and more nuanced picture of fruitful activities fostering generic competence development. Such perspective can enrich not only the formal curriculum and development of learning outcomes, but also support the development of pedagogical activities supporting students' development of generic competences by adopting a student-centred approach.

DANSK RESUME

Den samfundsmæssige udvikling og interdisciplinær afhængighed har øget behovet for kompetencer, der rækker på tværs af ingeniørpraksisser og disciplinære grænser. Uddannelsesinstitutioner spiller en central rolle i understøttelse af udviklingen af den enkelte ingeniørstuderendes kompetencer i en professionel praksis. I forskningen fremhæves blandt andet et øget institutionelt fokus på udvikling af professionel identitet og generisk kompetenceudvikling som middel til at nærme sig praksisfeltet. Forskningen præsenteret i denne afhandling tager udgangspunkt i det sidste, og undersøger hvordan generiske og PBL-kompetencer er konceptualiseret i et formelt og institutionaliseret perspektiv, og hvordan disse relaterer sig til de studerendes beskrivelser af egne erfaringer fra et PBL-curriculum.

Udviklingen af de studerendes generiske kompetencer fremhæves som et mål i flere pædagogiske tilgange, hvor generiske kompetencer således integreres både i formelle læringsmål og i undervisningspraksis. Problem-baseret læring (PBL) og *Conceive, Design, Implement, Operate* (CDIO) er begge eksempler på pædagogiske tilgange, og begge fremhæver også autentiske problemer og gruppebaseret projektarbejde som centrale principper for undervisningsaktiviteter. I projektarbejdet kan de studerende potentielt udvikle generiske kompetencer indenfor domæner såsom kollaborativ problemløsning, gruppearbejde og projektstyring. Der er dog en risiko for, at disse kompetencer med tiden bliver tavse, efterhånden som projektarbejdet kan blive mere uformelt og rutinepræget. For at understøtte de studerendes opmærksomhed og refleksion over egen kompetenceudvikling kan der anvendes forskellige metoder og aktiviteter såsom eksplicitte læringsmål, øvelser til øget refleksion eller pædagogiske tiltag, der kan fremme de studerendes generiske kompetencer. Disse metoder og aktiviteter er dog oftest baseret på andres erfaringer, og de studerendes bidrag til metoder og aktiviteter er ofte fraværende. I denne forbindelse omhandler afhandlingen ikke kun de studerendes opfattelser og oplevelser af generisk kompetenceudvikling, men også hvordan de studerendes erfaringer kan bidrage til udvikling af formelle læringsmål.

Afhandlingen er inspireret af curriculumteori og herunder fortolkninger af curriculum og undersøger generiske kompetencer fra flere perspektiver; et bredere udsnit på ingeniørstuderendes opfattelse af udvikling af generiske kompetencer på tværs af PBL-praksisser og situerede perspektiver vedrørende det intenderede og fortolkede curriculum med udgangspunkt i Aalborg Universitet (AAU), der anvendes som en kritisk case for systemisk integreret PBL.

Forskningen, der præsenteres i denne afhandling, er baseret på tre artikler: et litteraturstudie, der sammenfatter eksisterende empiriske undersøgelser omhandlende ingeniørstuderendes opfattelse af egen udvikling af generisk kompetencer i en PBL-kontekst, en teoretisk informeret indholdsanalyse af 10 bacheloruddannelsers formelle curricula fra AAU samt en tematisk analyse af 130 PBL-kompetenceprofiler fra ingeniørstuderende på tre af AAU's kandidatuddannelser.

Artikel I præsenterer et litteraturstudie af empiriske undersøgelser af ingeniørstuderendes opfattelse af udvikling af generiske kompetencer i PBL. Litteraturstudiet identificerer hvilke generiske kompetencer, der fremhæves i de inkluderede lartikler, og hvordan disse kompetencer uddybes og udvides som begreber. I litteraturstudiet påpeges flere problemstillinger, blandt andet at generiske kompetencer er utilstrækkeligt defineret og ofte kun overfladisk beskrevet. Litteraturstudiet afsluttes med række anbefalinger, såsom at man bør være opmærksom på de bestanddele, der udgør generiske kompetencer, for i tilstrækkelig grad at kunne analysere og forstå de studerendes generiske kompetenceudvikling.

I artikel II præsenteres en indholdsanalyse af 10 formelle curricula fra AAU. I artiklen undersøges forekomsten af eksplicitte læringsmål relateret til generiske kompetencer. Analyse viser, at hovedparten af læringsmål relateret til generiske kompetencer findes på første studieår. For størstedelen af de inkluderede uddannelser findes læringsmålene primært som en del af et introduktionskursus omhandlende PBL som en gennemgående model for studiepraksissen på AAU. De følgende semestre optræder læringsmålene mere sporadisk og er ofte ens på tværs af semestre og uddannelser. I artiklen diskuterer vi, om en mulig konsekvens af få læringsmål relateret til PBL potentielt kan gøre de studerendes PBL-praksis og generisk- og PBL-kompetenceudvikling tavs.

Artikel III er baseret på resultaterne fra artikel I og undersøger ingeniørstuderendes beskrivelser af teamwork-kompetencer fra deres PBL-praksis på AAU, og hvordan de studerendes erfaringer kan anvendes til udvikling af curriculum. En tematisk analyse af 130 studerendes PBL-kompetenceprofiler resulterede i konstruktionen af fem temaer: at finde komplementære kompetencer, at etablere en teamwork-kultur, at forebygge og håndtere konflikter, at være opmærksom på sig selv og andre og at have en fælles situeret bevidsthed. I artiklen finder vi, at ingeniørstuderende udvikler en øget opmærksomhed på sig selv, gruppemedlemmerne og deres position i gruppen under projektarbejde. Derudover viser vi også, at de studerende er fleksible i deres gruppearbejde for at kunne imødekomme uidentificerede udfordringer, der opstår i det interne eller eksterne miljø omkring gruppen.

De forskellige perspektiver på generiske og PBL-kompetencer præsenteret i afhandlingen viser, at PBL kan understøtte ingeniørstuderendes udvikling af generiske og PBL-kompetencer på tværs af PBL-praksisser. Mens læringsmålene relateret til generiske teamwork-kompetencer er generelle, viser den tematiske analyse en række temaer og detaljerede beskrivelser af generiske kompetencer og komponenter indlejret i de studerendes teamwork. Resultaterne indikerer, at inddragelse af de studerendes erfaringer kan give et rigere og mere nuanceret billede af undervisningsaktiviteter, der fremmer og understøtter udviklingen af generiske kompetencer. Et sådant perspektiv kan ikke kun berige det formelle curriculum og udviklingen af læringsmål, men også bidrage til udviklingen af pædagogiske aktiviteter, der støtter de studerendes udvikling af generiske kompetencer igennem en studentercentreret tilgang.

LIST OF ARTICLES

The thesis is based on three articles:

I. Boelt, A. M., Kolmos, A., & Holgaard, J. E. (2022). Literature review of students' perceptions of generic competence development in problem-based learning in engineering education. *European Journal of Engineering Education, 47*(6), 1399–1420.

II. Boelt, A. M., Kolmos, A., & Bertel, L. B. (2021). Facilitating Reflection and Progression in PBL: A Content Analysis of Generic Competences in Formal PBL Curricula. *Journal of Problem Based Learning in Higher Education*, *9*(1), 131–149.

III. Boelt, A. M, Holgaard, J. E, & Kolmos, A. (2023). A thematic analysis of engineering students' experiences of teamwork in problem-based learning. *International Journal of Engineering Education*, *39*(3), 627–642.

Related publications:

IV. Boelt, A. M., Kristensen, N. S., & Clausen, N. R. (2020). Classification and framing in PBL: A Case Study. I A. Guerra, A. Kolmos, M. Winther, & J. Chen (eds.), *Educate for the future: PBL, Sustainability and Digitalisation 2020* (1 ed., p. 343–353). Aalborg Universitetsforlag. International Research Symposium on PBL.

V. Boelt, A. M. & Clausen, N. R. (2023). Participant Direction. I A. Kolmos, & T. Ryberg (eds..), *PBL in a Digital Age* (p. 39–52). Aalborg Universitetsforlag. Studies into Problem Based Learning in Higher Education Nr. 3 https://vbn.aau.dk/en/publications/pbl-in-a-digital-age

VI. Bertel, L. B., Kolmos, A., & Boelt, A. M. (2021). Emerging PBL Futures: Exploring Normative Scenario Development as an approach to support Transformation in Problem-based Learning and Higher Education. *Journal of Problem Based Learning in Higher Education*, *9*(1), 200–216.

VII. Boelt, A. M., Kristensen, N. S., & Clausen, N. R. (2021). Experiences from implementation of a flipped and integrated semester structure and supporting baseline studies. Transforming PBL Through Hybrid Learning Models, 353–356.

VIII. Boelt, A. M., Clausen, N. R., & Bertel, L. B. (2019). A comparative curriculum analysis of two PBL engineering programs. SEFI 47th Annual Conference Proceedings, 1415–1423.

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I participated in the cross-faculty research project PBL Future with a cohort of senior researchers and PhD students, first as a research assistant from VILA and then as a PhD student myself. I want to thank all participants in PBL Future for fruitful discussion and new perspectives on PBL, Didaktik and pedagogical practices, and for letting me get a glimpse of what a cross-faculty and interdisciplinary research project looks like.

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I want to thank my follow PhD colleagues at the UCPBL for support and help when writing or work was troublesome. I want to thank Mia Thyrre Sørensen and in particular Nicolaj Riise Clausen for lending an eye and ear. I feel like we have become brothers in arms, as Knopfler sings – some of the metaphors may apply but much less dramatic, fortunately.

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TABLE OF CONTENTS

TABLE OF FIGURES

CHAPTER 1. INTRODUCTION

Social changes associated with the acceleration of society characterising late modernity are often framed as problems for capable engineers (UNESCO, 2010, 2021). In the UNESCO reports, engineering is positioned as a problem-solving profession situated at the centre of a diverse scope of global challenges such as ensuring economic growth, innovation and human development, reducing poverty and, lastly, addressing climate change and pollution. The scope of problems in late modernity are rapidly becoming more intangible, made opaque by several feedback loops caused by nonlinear interactions between humans and non-human actors in convoluted systems that are neither completely regular nor random, but emerging (Catalano, 2011). Such developments have prompted the push for a diverse and increasing range of capabilities and competences, each concerning individualised learners' different abilities, that seem to converge in contemporary issues such as sustainability (Beagon et al., 2022; Guerra, 2017), innovation (Charosky et al., 2022) and employability (Kolmos & Holgaard, 2019). Critically, in a modernism characterised by acceleration and dynamic stabilisation (Rosa, 2015, 2020), individual acquisition of an ever-increasing cluster of competences seems to be the answer.

Societal changes require engineers to work with emerging technologies and in changing economic markets, but also to have an ability to collaborate with a diverse cohort of stakeholders and professions when addressing problems (Siller et al., 2021). In an outline suggesting a new ontology of engineering, Siller et al. (2021) note that if current challenges are to be managed in a long-term perspective, approaches ought to consist of interdisciplinary approaches and knowledge developed by teams of engineers and professions based in the humanities and social sciences. Although developing a new ontology for engineering is an interesting proposal – but one outside the scope of this thesis – Siller et al. (2021) point to increased collaboration both within the diverse field of engineering and beyond, highlighting a need for competences that transcend preconceived disciplinary boundaries. Moreover, such competences are not isolated within a disciplinary context or even limited to the sphere of education or professional practice, but are relevant for individuals to lead a successful and responsible life and also for society in general to face contemporary and future challenges (Rychen & Salganik, 2003b). The emphasis on anticipated competences means educational institutions have become increasingly pivotal (and accountable) from both a societal and individual perspective while simultaneously being in a precarious position where they are lambasted should they not meet the expected ends (Labaree, 2008). In a more critical vein, Biesta (2006, 2013) outlines in a critique of what the author calls the *learnification* of educational discourse that the necessity for lifelong learning often comes through as a threat – without such capabilities the individual and even society are doomed for demise! The same is noted by Gorz (2010), who characterises modern human life as an increasingly entrepreneurial endeavour of endless self-optimisation.

Attempts to mitigate the gap between education and professional practice often materialise in various forms such as increased emphasis on expected outcomes, standardisations, or applications of pedagogical approaches. Similarly, several frameworks have aimed to capture competences needed for future individual and societal prosperity, often resulting in slight variances in emphasis of particular competences depending on national or organisational agendas, intended context for application and ideological perspectives on education (Tahirsylaj & Sundberg, 2020; Voogt & Roblin, 2012). Generally, frameworks address key, generic or transferable skills or competences such as teamwork, communication, problem-solving, creativity and variations of metacognitive abilities such as reflexivity and 'learning to learn' (Gonzáles & Wageneer, 2003; Rychen & Salganik, 2003b, 2003a; Voogt & Roblin, 2012). Consequently, the inclusion and development of such competences in educational programmes has meant curriculum revisions both on a local and global scale, perhaps most notably the Bologna Process and the transition from teacher-centred education to accountability-oriented student-centred learning (Adam, 2008; Biesta, 2016).

Most competence or skills-oriented frameworks cut across various educational domains, whereby classifications of generic competences are decontextualised and placed outside the context in which they are to be developed and enacted (Tahirsylaj & Sundberg, 2020). This is also seen in the Tuning project in which generic competences are defined as being subject independent (Gonzáles & Wageneer, 2003) and in the Bologna Process where the student has become a *learner* (Bologna Working Group on Qualifications Frameworks, 2005; Gonzáles & Wageneer, 2003) – an epithet transcending previous contextual classifications (Zapp, 2019). A different approach for engineering education is proposed by Male (2010), who finds that generic competences are to be conceptualised as an integrated and enabling part of engineering rather than existing as additions to professional practice. This proposition accentuates that some generic competences *are* contextually bound, and transferable within a specific professional domain (Male et al., 2011).

Some institutions have reformed their curricula and pedagogical approach in accordance with guidelines and principles provided in the *Conceive, Design, Implement, Operate* (CDIO) initiative, which aims to effectively support the education of engineering students equipped with both specialised knowledge and skills and social awareness – pre-professionals, ready-to-engineer (Crawley et al., 2014). Some institutions and researchers have opted for different modes of project- or problem-based approaches (hereafter PBL[1] – a more elaborate description will be presented in chapter 2), resulting in great variety in implementations, ranging from smaller course-based interventions to systematic integrations continuing throughout an entire educational programme (Chen et al., 2021; Kjersdam & Enemark, 1994). Student-centred pedagogies such as PBL are also suggested as viable pedagogical interventions aimed at supporting students' development of generic competences suitable for an unknown

[1] PjBL is another acronym roughly covering the same pedagogical principles. In this thesis, PBL designates both problem-based and project-oriented learning approaches; for readability it will be used exclusively.

future (Male et al., 2011; Voogt & Roblin, 2012). This has also been found in a longitudinal study set in systematically integrated PBL and CDIO environments, where students self-reported improvements of generic competences during their education – although simultaneously reporting less confidence in subject matter compared to peers from other learning environments (Kolmos et al., 2021).

Though studies bolster the potential of PBL in supporting students to develop suitable competences for the future, few studies address generic competences on their own. Furthermore, students appear to struggle with conceptualising generic competences as well – even in systemic integrated PBL (Holgaard & Kolmos, 2019), although such competences are explicitly stated as learning outcomes (Kolmos et al., 2021, p. 74). For engineering students in PBL, much of the curriculum is experienced as self- or participant-directed (Kolmos & De Graaff, 2014), and according to Schön (1983) practice can become habitual or too stable over time, thus potentially rendering generic and transversal knowledge tacit and acritical (Polanyi, 1972).[2] Hence, in a Schönian sense, educational practice needs to encompass more than the application of technical rationality and involve reflective practice. Practice can then also be a place of learning through intentional reflection, where a reflective practice takes form as a dialogue with past experiences and situations (Boud et al., 1985), and potentially in structured reflective refugia (Schön, 1983).

Contemporary emphasis on repositioning the curriculum as a pivotal managerial tool for organising education and outlining expected outcomes (and even in commodifying education, as noted by Hussey and Smith (2002)) can be considered an exemplar of technical rationality as outlined by Schön (1983). Practically, outcomes of yet-to-be-had experiences are defined for intended transparency and individual and institutional accountability (Gonzáles & Wageneer, 2003), whereas Hussey and Smith (2002) note that a "*proper interpretation of these outcomes must emerge from the context and prevailing activities and experiences of the students*" (p. 232). In what seems to be a comment on the school reforms of the early 1900s in America, outlined by Callahan (1962), in *How We Think* Dewey notes a linguistic turn in the framing of contemporary education (1978, p. 319):

> *Words can detach and preserve a meaning only when the meaning has been first involved in our own direct intercourse with things. To attempt to give a meaning through a word alone without any dealings with a thing is to deprive the word of intelligible signification; against this attempt, a tendency only too prevalent in education, reformers have protested*.

In other words, there is a need to supplement the notion of social efficiency characterising current conceptions of education described by Sarauw (2011) and Biesta (2013, 2016) with an experiential perspective from students. This does not, however,

[2] Polanyi (1972) writes of tacit knowledge, not transversal competences, but in my view the process of making knowledge explicit and "visible" shares traits with capturing and conceptualising generic competences.

entail a complete schism between formalised curricula and individual experience. As Dewey (1902) notes, the psychological aspect of experience and the logical ordering of subject matter are much akin to an explorer finding his way and the construction of a map once a country has been '*thoroughly explored*' (p. 18). The two are mutually dependent, but the latter would be of little meaning if not for the experiences of the explorer. Similarly, the experiences of the explorer would be of little benefit to others if no opportunity for comparison to the maps of previous explorers exist (Dewey, p. 18–19). Still, it must be acknowledged that *exploration* and *direction* are two different aspects of utilising a map. Polanyi (1972) provides an analogy like Dewey's, mainly that a map allows for comparisons: is the tree and the hill where it is supposed to be according to the map? If not, we must adjust our course or map, moving from internalised trial and error to externalised acritical assessment based on sensory inputs from the environment. In this light, insights into experienced curricula can provide students' explorations of the formalised map, and thus a guide for potential ends in sight (Dewey, 1902, p. 20).

Inspired by Brooman et al. (2015), I hope the emphasis on students' experiences can inform and qualify curricula – not necessarily only as expected outcomes or ends, but also as experiences of Others serving as examples of widening "*the external conditions for subsequent learning*" (Dewey, 1997b, p. 41), potentially without subordinating these as objective conditions founded in more mature experiences.

1.1. AIM AND RESEARCH QUESTIONS

The aim of this thesis is to inquire into conceptualisations and representations of generic and PBL competences as they appear from a formalised and institutionalised perspective, and how they emerge in students' articulations based on experiences in PBL. This leads to the overall research question:

How are generic and PBL competences conceptualised from a formalised and institutionalised perspective as intended outcomes, and how do they correspond in students' articulations of their experiences in a PBL curriculum?

The overall research question is addressed through three analytical perspectives: a) identification of existing literature documenting engineering students' generic competence development in engineering educations practicing a form of PBL; b) framing of generic competence in formal curricula exemplified as intended learning outcomes (ILO); and c) engineering students' experiences and articulations of generic competence in a PBL environment. The included articles address the following perspectives:

I. What landscape of generic competences unfolds by reviewing empirical research of student perceptions of generic competences in a PBL environment? (Article I)
II. How are generic competences specified explicitly as ILOs and integrated into the curriculum in a systematic PBL environment? (Article II)

III. How can engineering students' conceptualisations of specified generic competences enrich the understanding of these as an asset in curricula development? (Article III)

The approach applied in this thesis is a curriculum inquiry providing multiple entry points, each providing different perspectives on the curriculum, affording an opportunity for juxtaposition and comparison (Aoki, 2005). According to Aoki (2005), an educational programme cannot be evaluated in its entirety. Instead, Aoki (2005) outlines three general orientations for curriculum inquiry: an empirical-analytic orientation, a situational interpretive orientation and a critical theoretical orientation (p. 97). Each orientation is based on specific philosophies and aims of education, ranging from notions of efficiency and predictability to transformative reflection. I shall return to Aoki's curriculum inquiry later when outlining my research design in greater detail, but in my view the inquiry proposed by Aoki (2005) provides a framework to capture philosophies and teleologies of education that have elsewhere been described as being in "fundamental tension" (Westbury, 2002, p. 69). An overview of the thesis is outlined in Figure 1 below.

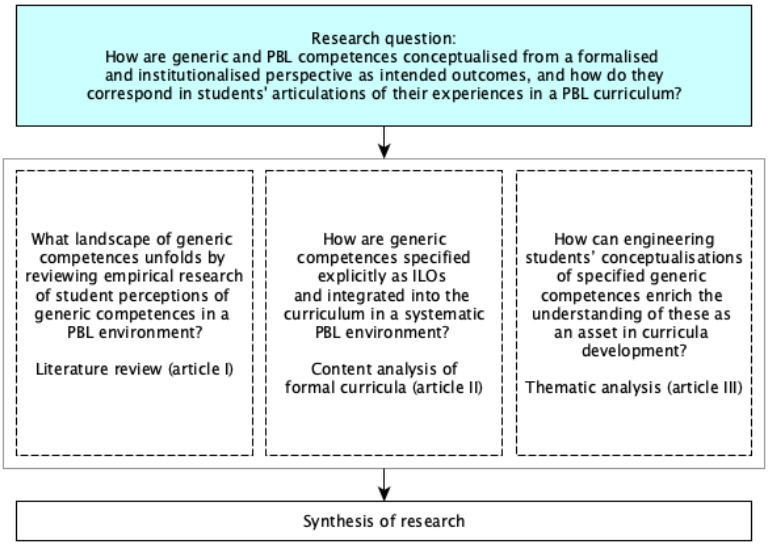

Figure 1. Outline of the research perspectives of the curriculum inquiry.

The first perspective is general and broad in its outlook (article I). Generic competences, and 'competence' in itself, is an ambiguous and 'fuzzy' concept (Le Deist & Winterton, 2005), and to that end a literature review is performed to provide an overview of existing research documenting engineering students' development of generic competences in PBL across varying modes of curricular integration. Hence, PBL is in this initial phase not limited to specific practices, but rather approaches adhering to the overarching principles described by Kolmos and De Graaff (2014), and ranges from course-based to systemic integrated PBL. As I shall demonstrate later, generic

competences cover multiple competences embedded in each other, thus covering generic competences in the concept's totality would in my view require more than a single PhD project. In this line of thought, the literature review not only provides an overview of existing research but also a direction for the remainder of the thesis. Using AAU as a critical case of systemic integrated PBL, this thesis explores local perspectives as to how generic competences are framed in formal curricula and how engineering students experience their PBL competence[3] development in PBL. The approach for synthesising the results of the articles will be described in more detail in chapter 3.

While Aoki's inquiry very much centres on the educational sphere, curriculum as a concept is malleable and dependent on ideological perspectives of education (Barnett & Coate, 2005; Kelly, 2004). According to Deng and Luke (2008), different philosophies and aspirations of education affect different layers of curriculum making. Policy and aspirations are enacted and interpreted differently across layers and by involved actors, and in this light the intended curriculum can be seen as a potential framing device for teachers' and students' enactment and interpretation of the intended curriculum. Kelly (2004, p. 6) captures the point more precisely:

> *By the official or planned curriculum is meant what is laid down in syllabuses, prospectuses and so on; the actual or received curriculum is the reality of the pupils' experience.*

According to Kelly (2004), a conception of a *curriculum* ought then to also include the relationship between intention and reality, and the gap between them. The notion is also buttressed by Erikson and Erikson (2018) who remark that learning outcomes are often derived from experiences more mature than those of students who are yet to experience the curriculum. To this end, representations of the received curriculum provide a "situated" perspective of those in the receiving end – although we will consider the *end* in constructivist pedagogical approaches as a more active co-construction than *received* signifies.

Articles I and II were initiated simultaneously, and whereas they both are general in their outlook on generic competences and include several competency domains, article III follows up on article II by analysing students' articulations of specific competences. Here, teamwork competences were chosen as a focal point based on the findings from article II. Figure 2 outlines the methods and purposes of the individual articles.

[3] In the next chapter *generic* will be replaced by a local distinction connecting competences more closely to the pedagogical approach at Aalborg University. I shall describe in more detail why – and why I opted for generic competences as a concept at the start of my project.

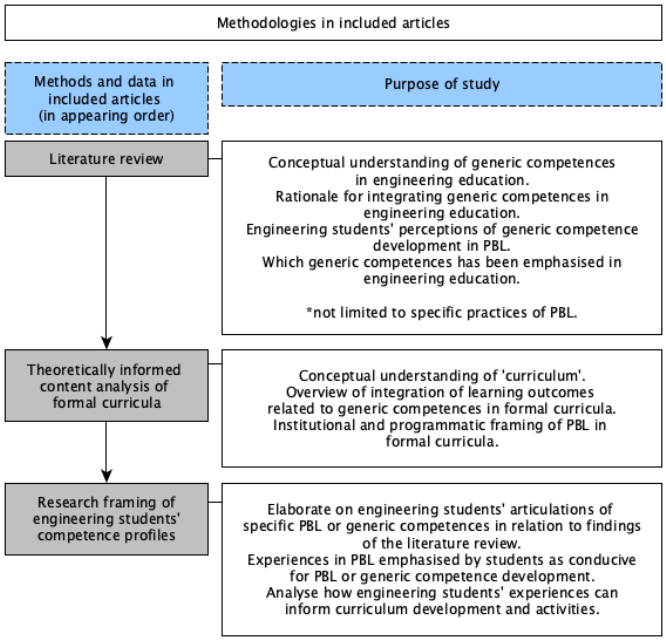

Figure 2. Methodologies and aims of the included articles.

Article I provides a literature review of articles reporting on empirical research of engineering students' generic competence development, including rationales for intervening in existing teaching, what competences the included articles emphasise and how the data was collected. The aim of the article is to provide an overview of existing research concerning students' perceptions of their generic competence development in PBL. The article contributes with a landscape of existing research on generic competences emphasised in engineering education, the methods used to do so and students' perceptions of generic competence development. Furthermore, the article is intended to inform and qualify a narrow selection of specific generic competences for further research in this thesis.

In parallel with article I, article II was written as part of a baseline study intended to inform sub-projects in the cross-faculty research project PBL Future at AAU.[4] The data analysed in article II is based on educational programmes already part of included sub-projects. Hence, the aim was to provide an overview of how PBL competences are framed as ILOs by conducting a content analysis of formal curricula from 10 different bachelor's programmes from the five faculties at AAU. As I shall demonstrate later, reflection of the individual learning process is primarily a student responsibility, and the article provides an overview of how and whether learning outcomes related to PBL can potentially aide such reflection. To this end, the article also provides some

[4] https://www.pblfuture.aau.dk/

insight into the formalised framing of PBL extending beyond the European Credit Transfer and Accumulation System (ECTS) usually describing the workload of projects.

Article III was developed in the wake of the findings of article I. The literature review showed that teamwork was a prevailing theme in the selected literature, though few articles unpack what teamwork consists of, and none from a student perspective. In article III we aim to elaborate on teamwork competences derived from students' experiences and to describe how students' experiences can inform curriculum development. The empirical data is students' PBL competences profiles developed as outcomes from what at the time was mandatory workshops, as described in the preceding section. Article III contributes with the presentation and analysis of a potential method to facilitate students' reflection of competence development (see Holgaard & Kolmos, 2021 for a guide to aid the development of students' PBL competence profile), as well as several constructed themes of teamwork competences.

1.2. OUTLINE OF THE THESIS

Chapter 1 presents the background for the research and aims for the thesis from a societal and individual perspective as well as how organisations and educational institutions have attended to those demands.

Chapter 2 presents a brief overview of early versions of the Danish rendition of PBL and principles informing current PBL practices not limited to a Danish context. Furthermore, this chapter also serves as an overview of the theories found in the included articles: the murky concept that is competence, and generic and teamwork competences. Before moving on to my conceptual framing of the research, I will provide a synthesis of competence in a PBL context based on the presented theories and pedagogical aspirations. I will end this section off with a short subsection discussing concerning generic competences and my initial reluctance to use the term 'PBL competences´ – which will hopefully also explain the hitherto use of generic competences rather than PBL competences.

Chapter 3 outlines my research methodology in general and for each of the included articles. Furthermore, I will introduce the research context and the PBL competence framework applied in the three included articles. The approaches are within a qualitative research paradigm, and in this chapter my intention is to show the relation between the three approaches found in the included articles. I will end the chapter by outlining the approach for synthesising the findings of each article in relation to the overall research question presented above.

In chapter 4 I provide condensed summaries of each article. Articles I and II present general findings regarding generic and PBL competences, whereas the third article presents findings focused on students' experiences of teamwork competences in a PBL environment. The chapter also provides a synthesis of the findings from the articles in relation to the overall research goal presented previously.

In chapter 5 I conclude my thesis and discuss my methodologies and findings. In addition to this, I outline suggestions for future research in PBL and generic competences development.

CHAPTER 2. “IF I KNEW THE JAZZ OF THE FUTURE, I’D PLAY IT”

The title of this chapter is found in the preface to Tenner’s (1997) *Why things bite back*, which resonates with the subject matter of this thesis: facilitating and developing anticipated competences suitable for whatever unknown future will emerge. Such an ambition requires not only adaptable canonical knowledge and competences, but also anticipatory competences and cultural awareness. Gratzinger (2012), for instance, describes how the telescope was invented near-simultaneously by several individuals, thus not a consequence of individual genius nor hero inventors, but one of cultural innovation. While Gratzinger (2012) describes problems with intellectual ownership rather than pedagogical innovation, the idea of cultural innovation and simultaneous invention is, I believe, transferable to the development of PBL; that is, the emergence of problem-based and project-organised approaches nearly simultaneous across the Atlantic.[5]

2.1. ORGANISING THE NOTES

The above will be the second-to-last jazz metaphor found in the thesis. I appreciate the organised chaos of improvisation, but I will try to impose some order on the following sections. Figure 3 shows the progression of this chapter, and how the topics are drawn together in conceptualising competences set in PBL as a conclusion to the chapter. The structure is inspired by Freire’s (1970/2017) approach, described as a movement through concentric circles from the general to the particular.

This thesis deals with the murky concept of competence (Le Deist and Winterton, 2005), and concerned with how PBL as a pedagogical philosophy and practice can support students' development of not only disciplinary competences but also those that are transferable across contexts. The first section of this chapter briefly addresses competence as a general concept, then from a perspective of engineering and engineering education. Next, teamwork competences are described. As a summary I provide a conceptual framing of suggested definitions of generic competences in a PBL framing.

[5] This is my attempt to avoid outlining a historic overview of international PBL development. For that see Servant-Miklos (2019). I am here primarily interested in the Danish variation.

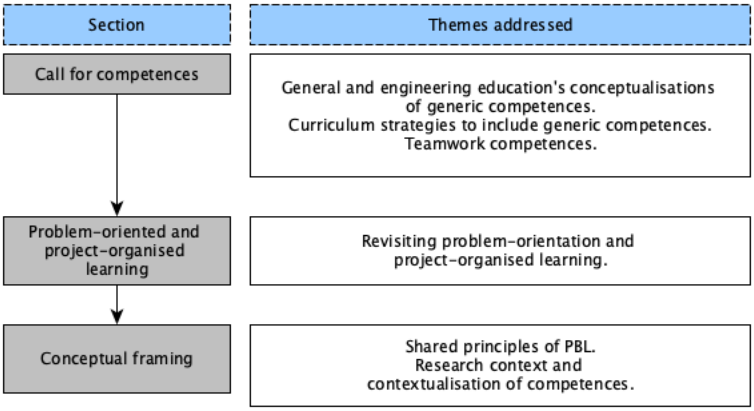

Figure 3. Themes in this chapter and their relation to PBL competences.

In this chapter I also want to address what I perceive as a fundamental ontological distinction between Illeris' alternative Didaktik[6] (1978, 1981) and the approaches to PBL found at McMaster and Maastricht Universities, mainly regarding the selection of problems. I think this perspective is important for at least two reasons: acknowledging the emotional and affective dimensions of entangled learning and action in problems addressed in PBL, and the ambition to abolish disciplines as the starting point for learning. In relation to the emotional and affective aspect, we shall later see how this is also embedded within the concept 'competence' described by Raven (2001) and Le Deist and Winterton (2005). Furthermore, I find the outline for an alternative Didaktik proposed by Illeris (1978, 1981) to align with and in many ways even foreshadow contemporary ideas of learning. I will towards the end of this chapter provide a small synthesis of my interpretation of generic competences in PBL based on theories and pedagogical aspirations presented in the following text.

While differences exist, so do similarities. Kolmos and De Graaff (2003, 2014) have on more than one occasion outlined several characteristics between models. The aim of this thesis it not to find a "gold-standard", as Savin-Baden (2020, p. 2) puts it:

> *The challenge we face is that despite efforts to establish problem-based learning as a legitimate approach to learning, uncertainty still prevails about the most effective way to implement it, with the result that new models, approaches and conceptual frameworks continue to emerge. The brinkmanship we face is the codification of staff and students' lives*

[6] When referring to Didaktik I will do so by writing *Didaktik* to signify the northern European pedagogical tradition concurring with the application found in Gundem and Hopmann (1998) and Westbury, Hopmann, and Riquarts (2010).

through signs, signposts and maps. These are characterized by benchmarks, and quality committees led by administrators who attempt to tame learning.

In my view this is precisely the strength of the defining characteristics outlined by Kolmos and De Graaff (2003) – they may be prescriptive, but have enough room for interpretations enabling a wide variety of untamed applications and models. I will present these shared and more recent principles informing PBL curriculum and practice later.

2.2. CALL OF COMPETENCES

In chapter 1 I described the general and overarching research question of this thesis, namely how generic and PBL competences are framed as outcomes in the formalised curriculum, and how this corresponds to students' articulations of experiences of the same in their PBL practice. However, clearly defining what competences are needed to prosper in the future is proving difficult – partly because of the yet-to-emergence and ephemeral aspect of anticipating and selecting competences (Rychen & Salganik, 2003b), but also because competence as a concept is poorly defined and often based on national ideological and implicit philosophical considerations (Le Deist & Winterton, 2005; Young & Chapman, 2010). To add even further challenges to efforts of defining skills, abilities and similar nouns, these are typically used interchangeably to describe roughly the same phenomenon. Rychen and Salganik (2003a, p. 4), for instance, use the term 'key competences' to describe a selection of key competences that are not independent and singular:

as constellations of multiple interrelated key competencies that take on different forms depending on contextual or cultural factors.

Here a competence is an embedded part of another competence, or as characterised by Murzi et al. (2020) in relation to teamwork competences, a multidimensional construct. Practically, this entails an understanding and conceptualisation expanding typical descriptions of competences denoted with only one describing adjective, such as 'collaborative,' 'communicative' or 'digital' competences. Furthermore, competences are not phenomena placed outside contexts and cultures or without individual attitudinal dispositions affecting competence in practice (Cannon-Bowers et al., 1995). According to Raven (2001), we often perceive ourselves as more competent while engaged in activities we enjoy, thus emphasising the content of an activity, our relation to it and that the requirements of engaging in the particular activity are constituents of how a competence comes into being. This triad also marks a malleability in the concept, making its use in an educational setting more fluid, as 'being competent' in the first semester is different than in the last. The proposed definition of competence as a function of context, individual and task is typically found in constructivist and phenomenological understandings of competence, where the triad form an entity (Le Deist & Winterton, 2005). Consequently, competence is not something an individual as such possess, but a relational phenomenon that appears in the interaction of individual

abilities and role requirements in specific situations (Raven, 2001). However, competences as such are not only what emerge in interaction. In an analysis of engine optimisers, Sandberg (2000) found that conceptions and experience of work preceded and defined what competences were used and developed during the performance of that work.

> *It is the worker's ways of conceiving work that make up, form, and organize their knowledge and skills into distinctive competences in performing their work.* (Sandberg, 2000, p. 20–21)

Rather than conceptualising competences as a rationalistic acquiring of attributes, changes in conceptions of work marks a different route to understanding individual competence development. A deep or rich conception of tasks and work would, according to Sandberg (2000), show in competent performance of tasks or work. In an educational context I think this is an important point to which I shall return later.

Defining and selecting competences is not a neutral process, but one in which the vision of society and societal objects becomes explicit (Rychen & Salganik, 2003b). In other words, selection of competences is a value-based and subjective activity. To this end, I find Castells' (2000) descriptions of the globalised network economy evocative. Globalisation, Castells (2000) writes, is highly selective, linking up everything that is deemed valuable by dominant interests, while discarding anything, be it people, firms, territories or resources, that has no value, in a 'geometry of creative destruction and destructive creation of value' (p. 10). One of Tahirsylaj and Sundberg's (2020) conclusions of their review of 21st century competences is that the dominant paradigms influencing definitions of competence are related to ideas of social efficiency and human capital theory (see also Salganik et al., 1999), but foregrounded by learner-centred curricula ideologies, echoing a sentiment put forward by Kvale (2004).

The anticipated outcomes of student-centred learning are epitomised in diverse educational frameworks used for accreditation or framing future competences (OECD, 2017; Rychen & Salganik, 2003a; Tymon, 2013; Woollacott, 2009). Furthermore, the idea of a *learning society* promoted in the last few decades has resulted in the advent of competence-oriented education, in which there is an increased demand for 'more protagonism' of individual students, amplified transparency in expected outcomes and changing roles for teachers (Adam, 2008; Gonzáles & Wageneer, 2003) – and often in internal conflict with learning philosophies drawn to the forefront (see for instance Stoller, 2015, 2018). Notably, this had consequences for educational institutions that had to adapt to an increasing accountability regime and standardisations (Biesta, 2016; Karseth, 2008) across Europe with the advent of the ECTS. Here I often find myself prone to picturing a furious battle between educational institutions and a leviathan of soft governance, but according to several researchers (Bernstein, 1977; Doll, 2008; Lundgren, 2015) the culture of curriculum is Protestant and has a lineage from Pretus Ramus

> *"himself, through Johann Comenius and René Descartes, into Puritan thought on both sides of the Atlantic, then into New England schooling, to*

> *American 19th century schoolbooks and that century's efficiency movement (epitomized by Frederick Taylor), and comes to culmination in what today is known as the Tyler Rationale.* (Doll, 2008, p. 12–13)

Though it may seem like whiggish history, the curriculum has a legacy of external factors influencing the teleology of education. It is, I admit, a deviation from the course of this thesis, but a reminder that external influence on education is not all new, although perspectives are different and reforms more regular (Steiner-Khamsi, 2009).[7] However, Kvale (2004) argues that while schooling served a disciplinary orientation in the industrialised societies, modern critical pedagogies are more attuned to a consumerist society by placing the individual student's needs and desires at the centre. The personalised learning trajectory can be viewed as another example of this trend, where collective education is by some authors considered to be cast aside in the increased emphasis on individual learning (see for instance Biesta, 2006 and Zapp, 2019).[8]

GENERIC COMPETENCES IN ENGINEERING EDUCATION

Generic competences have similar traits as the key competences outlined by Rychen and Salganik (2003), mainly that they apply across contexts and domains and that they are important from an individual and societal perspective (Wageneer & Gonzáles, 2003). In the Tuning Process, a list of 85 different generic skills and competences were identified and later classified into three overarching clusters (Wageneer & Gonzáles, 2004, p. 70–71):

- *Instrumental competences*: having an instrumental function such as cognitive and technological capacity and skills.
- *Interpersonal competences*: individual abilities relating to reflexivity and social skills in social interaction and co-operation.
- *Systemic competences*: skills and abilities concerning whole systems, and consists of knowledge, sensitivity and understanding that allows one to see how parts of a whole are related and come together. Requires prior acquisition of instrumental and interpersonal competences.

Each of these consists of several components recognisable from other frameworks describing generic competences (Tahirsylaj & Sundberg, 2020; Voogt & Roblin,

[7] For a thorough discussion of the advent of competence-orientation in education see Sarauw (2011).

[8] In the afterword to his outline of an alternative Didaktik, Illeris (1978) draws attention to how his book aligns with the thoughts of the 'clever people from Børsen in Denmark and OECD', who emphasise that primarily useful (applicable) knowledge is of value. Similarly, Illeris (1978) questions why we still need subjects such as ancient Greek history or philosophy in high school – the uselessness implied.

2012): problem-solving, planning, teamwork, communication, multicultural appreciation, leadership and grit, to name a few. While generic competences are important to prosper in a wide variety of aspects, occupational or societal, in engineering education they are part of the gap between practice and profession (Male, 2010). For engineers, generic competences include many of the competences described previously, and thus extend limited depictions of engineers as solitary problem-solvers equipped primarily with technical competences. One might even go so far, in deliberate provocation, as to characterise the disciplinary and generic competences in engineering as part of masculine and feminine engineering identities (see for instance Chen et al., 2022; Faulkner, 2007; Hyldgaard Christensen & Ernø-Kjølhede, 2006).[9]

The key or generic competences described by Rychen and Salganik (2003a) and Wageneer and Gonzáles (2003) are malleable to suit any context. Male (2010) writes that generic competences are those that are important to *all* students, and applies the term *generic engineering competence* to delineate those competences that are important across all engineering disciplines and of relevance to engineering students and practitioners. According to Male (2010), communication and teamwork are frequently rated as important generic engineering competences, follow by attitudes concerning integrity and commitment, problem-solving and the ability to learn (p. 32). Similar findings have been reported by Passow and Passow (2017) who find problem-solving, communication and teamwork to be among the most important or highly rated generic competences for engineers. Furthermore, the authors find that engineering work is often project based, 'tied to the life cycle of a product, process or system', and that:

> *The interrelationships among generic engineering competencies extend beyond the inseparability of technical and collaborative activities.* (Passow & Passow, p. 500)

From a pedagogical perspective engineering education should provide students opportunities for collaborative activities in environments and framings that require coordination of multiple competences (Male et al., 2011; Passow & Passow, 2017). Such a conception of generic engineering competences also has consequences regarding how these are understood and integrated into existing engineering education. Rather than conceiving of generic competences as external to technical and disciplinary competences, they are integral enablers of professional practice in and outside education (see for instance Barrie, 2006 and Hyldgaard Christensen & Ernø-Kjølhede, 2006). To address such aspirations, pedagogical models oriented towards team-based and project-organised problem-solving activities are often highlighted (Kjersdam & Enemark, 1994; Male et al., 2011; Voogt & Roblin, 2012).

[9] This might also be why some are reacting against the classification of generic competences as soft skills.

Implementing generic engineering competence into the curriculum can take various forms. Kolmos (2017) describes three strategies for integrating PBL into the curriculum, but the same strategies can be applied when aiming to integrate generic competences (see Voogt & Roblin, 2012):

1. An add-on strategy
2. An integrating strategy
3. A rebuilding strategy

The first is the most widespread strategy and is less obstructive to existing practice. The individual teachers are here the primary vehicle for adding additional content or new activities to existing courses under their control. Often such course-based transitions are of shorter durations. The second strategy requires more coordination within the educational institution as competences and projects are integrated across courses and disciplines on the entire curriculum. This strategy is also the most prominent in the frameworks describing 21st century skills due to their '*cross-disciplinary nature'* (Voogt & Roblin, 2012). The last strategy is concerned with the restructuring of the entire curriculum. This is mostly noticeable when new institutions emerge, or new programmes are created and emphasises the social context as a starting point for learning (Kolmos, 2017). In the next chapter, the contours of such a process are described.

TEAMWORK COMPETENCES

As seen previously, generic competences cover a variety of competences with and without context. Though it is perhaps premature to delve too deeply into the results of my own research, the literature review indicates that even though teamwork and communication are competences primarily addressed in the research, only a very few studies unpacked generic competences embedded within the concept of teamwork. Considering that *a* competence is an entity comprised of other competences working in some coordinated effort (Murzi et al., 2020; Passow & Passow, 2017), I decide to home in on teamwork competences and engineering students' conceptions and experiences of these in their PBL practice.

In a literature review of research articles, applications of team efficiency models from industrial and organisational (I/O) psychology and reviews of team effectiveness, Borrego et al. (2013, p. 488) summarise five psychological constructs of 'particular relevance to engineering students' and teachers: social loafing, interdependence, conflict, trust and shared mental models. Each of these constructs covers different dimensions of team efficiency, such as level of reliance on other people, diverging views among team members in relation to a project or task and shared knowledge structures that enable teams to coordinate action and adapt their behaviour – in short: the perception of tasks and peers. While such constructs indeed point to the multidimensionality of teamwork, the authors find that most team efficiency models focus primarily on input to teams and not processes and the development of skills for future application (Borrego et al., 2013, p. 482). Even so, the authors outline specific pedagogical

strategies based on the potential implications of the constructs (Borrego et al., 2013, p. 497):

- *Activities for setting goals, targets, and interaction rules for team members.*
- *Structures that scaffold students toward success without micromanaging them.*
- *Explicit discussion items for teams, including interaction rules, expectations, and how to deal with conflict.*
- *Guidelines for forming smaller teams, allowing students to self-select and even switch teams after a trial period (for longer or more intensive projects).*
- *Exercises for interdisciplinary team members to develop understanding and mutual respect.*
- *Grading schemes that motivate participation in team projects.*

These points have previously been mentioned in relation to engineering education in different guises (Jonassen et al., 2006; Trevelyan, 2010), foregrounding professional practice as a point of departure for pedagogical models. Still, for students to reflect on and constructively conceptualise their teamwork competences, knowledge is required for the identification of these competences (Necchi et al., 2020). According to Necchi et al. (2020, p. 330) this includes principles and concepts of effective and functioning teams, skills and appropriate attitudes that support the team's function. In their review of teamwork competences, Cannon-Bowers et al. (1995) capture both necessary competences while also emphasising the attitudinal dispositions needed to support teamwork, but also the situational and organisational conditions. Much like the constructivist conception of competence presented previously (see Le Deist & Winterton, 2005), Cannon-Bowers et al. (1995) emphasise that team performance can only be understood in relation to the contextual conditions and environments in which a task, performance or training is situated. Synthesising the selected literature, the authors find a set of core skills (Cannon-Bowers et al., 1995, p. 345–346): adaptability, shared situational awareness, performance monitoring and feedback, leadership/team management, interpersonal relations, coordination, communication and decision making. The list should not be interpreted as a definition of teamwork, and each of the core skills are comprised of processes, skills and abilities of both the team as an entity and the individual members. Furthermore, individual affective and attitudinal factors have a significant influence on team performance. Hence, an individual's conception of teamwork, collective orientation and cooperative behaviour, and team-level attitudes concerning topics such as collective efficacy beliefs, cohesion and team morale also play a part in the overall performance of teams.

Pedagogically, the descriptions of teamwork practices and competences mean that engineering students should engage in learning activities that foster and promote such development (Borrego et al., 2013). To critically assess their generic competences, practice through projects is, as noted by Necchi et al. (2020), not enough on its own. Practice must be supported by knowledge of the multidimensionality of competence as a concept, and the interrelated coordination of competences required by the context.

This can be framed as part of ILOs. However, in concordance with the described interrelated connection and coordination of technical and generic competences by Rychen and Salganik (2003), teamwork competences should be explicitly embedded in engineering students' practice, not only as intended outcomes but as part of disciplinary content emphasising teamwork competences' contextual conditions – and potentially the anticipated coordination of competences expected for team performance noted by Cannon-Bowers et al. (1995).

2.3. PROBLEM-BASED LEARNING

In the days of yesteryear – the 1960s and 70s – new pedagogical approaches emerged as a team of disgruntled doctors at McMaster University were displeased with their existing teaching practice and wanted to provide students with a less boring experience (Servant-Miklos, 2019). However, Servant-Miklos (2019) remarks that PBL at McMaster did not appear out the blue, but rather that cultural and economic conditions at the time were ripe for experimentation. So was the case in Denmark, and following the youth revolts in the 1960s suggestions for alternative pedagogical models and Didaktik emerged, and from their inauguration became part of two Danish reform-universities' identities (Whitehead, 1981).

PROBLEM-ORIENTED AND PROJECT-ORGANISED LEARNING

Near-simultaneously, two Danish reform-universities were established, both practising a pedagogical approach consisting of problem-orientation and participant direction (Kolmos & De Graaff, 2014). Though modes of PBL are in general distinctive in their approaches (steps, tutoring, problem identification and definition, to name a few), what is most striking, in my view, is the cause of change and the ideological foundations. If we accept the notion of "providing-a-less-boring-experience" put forward by Servant-Miklos (2019),[10] then the Danish rendition of PBL is more radical in its outlook from a societal and ideological perspective. A potential cause for this is the existing conditions set in the youth revolt of the 1960s, and the subsequent struggle to dismantle the ivory towers in higher education (Illeris, 1981; Servant-Miklos et al., 2019). Illeris (1978), who is often pictured as a central actor in the Danish[11] version of PBL (Kolmos et al., 2004), starts his advancement for educational reform in socie-

[10] In the book *Modkvalificeringens pædagogik – problemorientering, deltagerstyring og eksemplarisk indlæring*, Illeris (1981) addresses a critique of his book from 1978 that one might also direct towards the ambition of a "less boring experience" found in Servant (2019), mainly that educational institutions also serve as placeholders for people, and it is easy to retain students who are not bored, which is why politicians like PBL (according to Gunner Sundgren, in Illeris, 1981, p. 11).

[11] The "Danish version" may be too much of a reduction of the differences between the PBL practice at AAU and Roskilde University (RUC).

tal conditions such as new means of production and the adjacent need for new categories of qualifications in a "*modern, complicated, capitalist society*" (Illeris, 1978, p. 31, my translation). To realise such aspirations, Illeris (1978, 1981) proposes problem-orientation and participant-direction in conjunction with exemplarity as Didaktik principles, which mostly still stand today.

An essential tenet in Illeris' (1978; 1981) suggestions for a new Didaktik is an abolition of disciplines and disciplinary boundaries as the initial starting point for students' inquiry. Disciplines are no longer to be perceived as categorisations determining how educational programmes are organised. Hence, a participant-directed and problem-oriented Didaktik needs to be substantiated by meaningful and relevant themes or problems. Building on Dewey, Rogers, Anglo-Saxon curriculum theory and planning, Wagenschein's exemplarisches Lernen, communicative and dialogically oriented Didaktik and, lastly, Negt's notions of sociological imagination and exemplary learning, Illeris (1978, p. 170–190) deduces three principles for selecting suitable problems and themes – both from societal and subjective psychological perspectives (Illeris, 1978, p. 187–188, my translation):

1. Themes must be experienced as immediately relevant problems or fields of problems for the individual participant and shared among all participants.
2. Themes must be of such a quality that for the participants they can serve to elucidate the existing societal structures and their conditions.
3. Themes must include, in combination or in relation to other teaching activities, relevant or established subject matter of the respective educational programme.

The principles outlined above do, however, not entail complete freedom for participants, as external requirements such as relation and relevance to the labour market, accreditation, examinations and types of evaluations, societal aspirations, ideology and the purpose of education (Illeris, 1981, p. 118–130) also influence the selection of themes and pedagogical practice. Some of these external requirements, Illeris (1981, p. 128) notes, can pose a risk to participant-direction; if types of evaluations or examinations do not align with learning activities, external factors can work against the intentions of the pedagogical practice.

In addition to the three principles for selecting suitable problems from a subjective, objective and relevance perspective, Illeris (1981) adds a criterion called *Handlinsgkriteriet* (which roughly translates to "criterion of action"). The social-psychological conditions of participant-direction entails action, not only for the sake of motivation, but for the emotional involvement and epistemological dimensions that are part of action (Illeris, 1981, p. 114). Working with problems in project-organisation is a transition from traditional lecture-based and teacher-controlled education to an educational philosophy emphasising emotional and meaningful learning activities, collaboration and personal responsibility combined with disciplinary and intellectual development (Berthelsen et al., 1996).

In the 1990s problems appear to become closer related to professional practice, and theory something to be applied in practice – and as such not thought of as a continuum, as noted by Dewey (1997a). Kjersdam and Enemark (1994), for instance, write that practice and theory stand in a dialectic relation rather than being integrated in a continuum. Furthermore, while sociological imagination was pivotal in Illeris (1978; 1981) and Berthelsen et al. (1996), in Kjersdam and Enemark (1994) there is an increased emphasis on professional practice and problems and instrumental problem-solving. Like Illeris (1978), Kjersdam and Enemark (1994) remark that themes should provide core elements of subject matter, and that the application of subject matter should be explored through project work in professional practice and society. While the selection of themes in Illeris (1978) is also politically oriented, in Kjersdam and Enemark (1994) such a criterion is no longer a requirement. Instead, we find criteria such as hierarchical organisation of knowledge (which according to Reid (1998) is often characteristic of Anglo-Saxon curricula), general expression of themes to provide for a broad range of subjects in the project, and that themes should constitute the professional profile of an education. Adhering to these criteria will enable quick adjustment of the curriculum and content required by external technological and professional development (Kjersdam & Enemark, 1994). Problems may then be authentic and professionally contextualised, and thus in my reading becoming more akin to Kuhnian exemplars (Kuhn, 1970), not as those found in normal science but instead of professional practice, providing professional puzzles that are both realistic and manageable for students. This is also reflected in the learning environment at AAU, where due to overload in programmes with hitherto interdisciplinary main groups in the first semester, departments instead wanted more disciplinary content. Thus, themes became narrower and collaboration within departments became easier because of a shared scientific language (Kolmos et al., 2019).[12]

According to Illeris (2019, p. 59), a primary focus for the pedagogical innovations proposed by Illeris and his peers in the 1970s was the disbandment of elitist and backward liberal education or Bildung. This does, however, not entail the complete dismissal of personal development one might find in conceptualisations of Bildung. Berthelsen et al. (1996) note that previous participants in project work in education stressed both personal development *and* disciplinary development as outcomes of working in projects. However, as seen previously in relation to competence development, personal development can and should also be supported by systematic work and does not necessarily appear on its own – even in a PBL environment. In newer PBL curricula, process skills such as self-directed learning, project management and communication are 'taught in an integrated way' where students reflect on their practice (Edström & Kolmos, 2014).

[12] Whether this change in organisation is a cause or correlated to a more vocational focus is not present in the article by Kolmos et al. (2019) or Kjersdam and Enemark (1994). Hence, it is merely an observation.

CHARACTERISTICS OF PBL

The previous section primarily addressed the selection of appropriate problems and themes. The principles of participant-direction from the Danish reform universities and student-centred learning found at McMaster University and Maastricht University (Servant-Miklos et al., 2019) diverge in duration, roles and the position of tutors, facilitators and teachers in specific projects or steps (Dolmans et al., 2005; Kolmos & De Graaff, 2014). However, between the approaches general characteristics can be synthesised in three overarching but interconnected principles of PBL (Kolmos & De Graaff, 2014):

- A learning approach centred on working with problems and the identification, analysis and solutions to the proposed problem. The problem is the starting point, reference for and purpose of the learning process, meaning that the problem also focuses the selection of context for students. As seen previously, ownership is a central component in the learning approach, and pedagogical considerations concerning ownership should be taken into account if the problem is provided by the teacher. A problem can be authentic, practical or theoretical depending on the combination and objectives of the learning process. Furthermore, a problem can be organised in different learning processes such as case-based or project-based learning, where problems can be pre- or ill-defined.

- A social approach to learning, where learning is thought of as a collaborative social act founded in dialogue and communication. This requires students to interact with peers in teams sharing knowledge and organising the process of collaborative knowledge construction. This principle also covers the concept of participant-direction described previously and indicates the collaborative ownership and negotiation of the learning process.

- The third principle concerns the approach to content. PBL involves interdisciplinary learning not limited to subject-related boundaries as knowledge from different disciplines is necessary for students when working with real life problems. It follows that if problems are disciplinary in focus, an analysis and solutions can have limitations which need to be acknowledged. If students have an opportunity to choose a project within a theme, exemplary practice[13] is an important principle aiming to ensure that the content of a project is exemplary to the whole, or that the outcome is in concordance with overall objectives. Students analysing and solving problems apply theories, thus enhancing an understanding of the relation between theory and practice much akin to typical research process.

[13] I am unsure whether exemplary practice is the same as exemplary learning known from Negt or Wagenschein.

The three overarching principles allow for a wide variety of PBL practices suited to specific contexts and educational programmes. The principles also enable different strategies for the presented curriculum revisions, and an add-on strategy for single courses may provide teachers and students with new experiences. This add-on approach is the case for the majority for PBL practices in engineering education (Chen et al., 2021), and in relation to competence development discrepancies between types of PBL practices are bound to occur.

The PBL principles above (Kolmos & De Graaff, 2014; Illeris, 1978, 1981), the psychological constructs for team performance (Borrego et al., 2013) and teamwork competences (Cannon-Bowers et al., 1995) correlate regarding several aspects. If adhering to principles and adjusting pedagogical considerations and learning activities accordingly, then PBL affords students development in terms of several competences. However, as competent enactment is a process of coordination of competences, we can follow Savin-Baden's (2020) suggestion and explore components and concepts to imagine new PBL pedagogies. Savin-Baden (2020) describes five imaginary PBL pedagogies, departing from themes such as restricted Socratic teachings known from Meno (see Hopmann, 2007), deliberate facilitation of uncertainty and changes in both problems and processes for students, and liminality and threshold concepts concerning oscillating changes in identity and subjectivity (see Rattray, 2016; Savin-Baden, 2016). In a similar vein, if we want engineering students to develop competences to adapt to unforeseen and emerging impediments, then carefully orchestrated disturbances and disruptions in students' teamwork is a potential route (for inspiration see Overton & Randles, 2015).

CONCEPTUALISATION OF COMPETENCES IN PBL

As demonstrated above, competence is a multidimensional construction where multiple competences work in coordinated effort to display *a* competence in relation to a particular activity (Raven, 2004; Rychen & Salganik, 2003a). Moreover, it has been found that generic competences also act as enablers of professional practice and not as entities existing as externalities of practice (Woollacoot, 2009), though in an interrelated mesh extending beyond the inseparability of technical and collaborative activities (Borrego et al., 2013).

Focusing on teamwork competences it is seen that members' individual attitudinal dispositions also influence team performance, and that contexts need to be considered or included when assessing particular competences (Cannon-Bowers et al., 1995). In Figure 4 below, the theoretical outlines of competence have been summarised in a conceptual model.

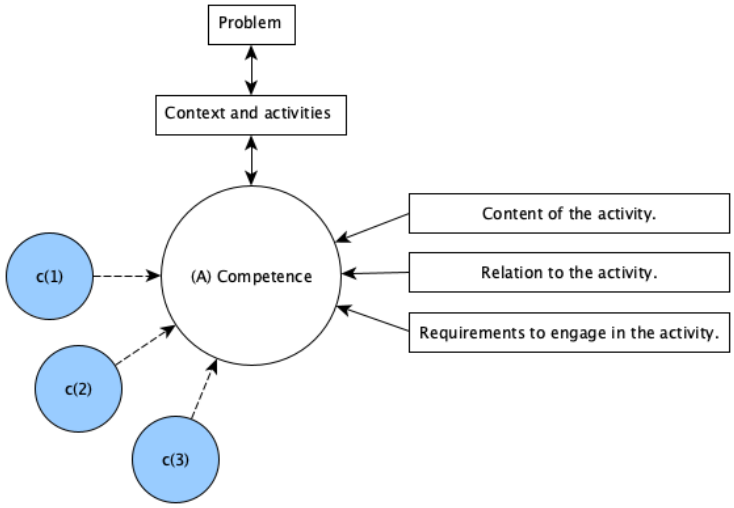

Figure 4. Conceptual model of a PBL competence.

A competence is an entity consisting of competences c(1)–c(n), in some coordinated effort. Moreover, a competence can be considered as a relational phenomenon determined by the content of the activity, relation to the activity and the requirements of the activity. Consequently, a single competence[14] is comprised by this triad in conjunction with triads of other competences and manifests itself in relation to specific contexts and activities derived from a problem. Additionally, this relation is determined by personal dispositions related to the contexts, activities and problems (Cannon-Bowers, 1995; Raven, 2004). Assessing and reflecting on generic competence development then require students to be attentive to the coordinated effort, context and activities. To this end, I consider PBL competences a coordination of competences appearing in the relation to specific PBL contexts and activities determined by a problem. However, as with the multidimensional construct that is competence, problems in a PBL environment – if considered as more than *the* exemplary and disciplinary problem starting the initial learning process – can appear throughout the entire process. For instance, the principle presented by Kolmos and De Graaff (2014) concerning the social aspect of PBL emphasises that the learning process is a social and negotiated practice which in itself must require coordination of specific competences by each team member to warrant team performance. Managing problems is then for students not limited to a thematic and disciplinary problem alone but extends to the totality of challenges emerging within the PBL environment and beyond, affecting teamwork.

From the perspective of curricular development, the affective and personal dimensions of competences are challenging to capture, and one could rightfully question

[14] Following the theoretical dispositions outlined above, I am not sure that using "a single competence" or "a competence" is a good conceptualisation.

whether it is something that educational institutions should capture at all (MacFarlane, 2016). The proposed emotional engagement of participant direction outlined by Illeris (1978) ought to, from a theoretical level at least, supply students with a meaningful relation to selected problems. This does, however, not entail that this is also the case with other emerging challenges in students' PBL. The inclusion of individual attitudes does pose a problem when framing educational practices from a formalised perspective, and as seen above is clearly important when assessing competences at work. Still, the question remains as to how much of an individual an institution can attempt to control and include in its aims for assessing personal dispositions, and where the boundary between the public and private spheres resides for the individual student (Kvale, 2004; Macfarlane, 2017). Hence, reflective writing in competence profiles provides students an opportunity for selecting the boundary of the private sphere. Such an approach affords a glimpse into personal disposition and contexts, albeit with no assurance that the documents represent complete reality (Clark et al., 2021) – a point to which I shall return later.

2.4. CONCEPTUAL FRAMING

The learning activities in PBL ought to provide ample opportunities for students to engage in processes and collaborative knowledge construction, and thus to develop a diverse set of generic competences.

My inclination to include students' perspectives is based on Illeris' (1978, 1981) concept of participant-direction, where students have a substantial influence on the totality of experience in an institutional setting. Initial scoping searches of potential literature showed that research primarily concerns staff members' observations of students' generic competence development and student perspectives. As Aoki (2004) notes, a programme cannot be fully grasped, but multiple perspectives on a curriculum provides a more holistic picture. Here, the curriculum extends beyond local contexts and includes a myriad of PBL practices to provide more of an overview of how engineering students' perceptions of generic competences have been researched and emphasised in engineering education:

1. What landscape of generic competences unfolds by reviewing empirical research of student perceptions of generic competences in a PBL environment? (Article I)

Formal curricula and learning outcomes are repositioned as vital instruments in the transition from teaching to learning (Adam, 2008; Marope, 2017), and institutional framing of generic competences in formal curricula may be a viable entry point to research how specific competences are explicitly stated to students. ILOs are, however, not the same as theories, but adhering to the Dublin Descriptors should indicate specified types of expected outcomes to students (Bologna Working Group on Qualifications Frameworks, 2005). Conducting a local curriculum inquiry using AAU as a critical case of systemic PBL integration, we research how generic competences are stated from an institutional perspective in formal curricula, hence:

2. How are generic competences specified explicitly as ILOs and integrated into the curriculum in a systematic PBL environment? (Article II)

As mentioned previously, competences are not devoid of context. Like the former research question, this one is contextually set at AAU, which again serves as a critical case to research how engineering students in systemic PBL conceptualise the development of teamwork competences in their reflective writings:

3. How can engineering students' conceptualisations of teamwork competences enrich the understanding of teamwork as an asset in curricula development? (Article III)

CHAPTER 3. METHODOLOGY

In this chapter I will outline the methodology employed in the thesis and each article. I will start by introducing the context of the research presented in the articles, which for the most part has taken place at AAU. The aim of the project is to understand how generic and PBL competences are conceptualised from a formalised perspective, and how they manifest in students' articulations of their experiences in a systemic PBL curriculum. To do so, the methodological approach caters to different contexts and levels of curriculum making.

3.1. CONTEXT FOR RESEARCH

The research is primarily conducted at AAU where PBL is systemically integrated into all educational programmes across all semesters. The principles guiding the project-organised PBL at AAU is much akin to the general ones presented in the previous chapter, and students spend approximately half their time studying and engaged in projects, albeit with local variations (Kolmos et al., 2004). Organising the curriculum around themes allows for greater flexibility in relation to content as well as professional and societal developments (Kjersdam & Enemark, 1994). Problems can be organised and integrated into projects as three different types: a teacher-controlled assignment project where problem, subject and methods are chosen for students; a subject project where students have free choice of either problems within a subject or among methods; and, lastly, a problem project where a problem is the starting point. In the latter, the problem determines disciplines and methods, and is often characterised as an interdisciplinary project (Kolmos, 1996). This does not, however, entail that the curriculum is in constant flux, but is rather an evolving hybrid of canonical knowledge and course-based learning activities in combination with participant-directed projects (Edström & Kolmos, 2014). A semester consists of a workload of 30 ECTS, where half of the activities are typically based on project work and the remaining 15 ECTS divided between courses primarily covering the discipline (Edström & Kolmos, 2014, p. 546; Kolmos et al., 2004).

The approach at AAU has been formalised as the AAU PBL model (Kjersdam & Enemark, 1994; Kolmos et al., 2004), and is based on six basic principles (Aalborg University, 2015, p. 4–5):

- *The problem is the starting point for learning.* Problems can be theoretical and practical and must be authentic and scientifically based. A problem must also be of relevance outside academia, comprehensible for the students, and may be analysed and solved using an interdisciplinary approach.

- *Project organisation creates the framework of PBL.* The project organisation defines the temporal aspect and boundaries of the activities that must be met

before a predefined deadline and anticipated target. Activities typically involve identification, analysis and solutions to a problem specified by a problem formulation.

- *Courses support project work*. Students participate in lectures, workshops, exercises and seminars providing theories and methods to support the project work.

- *Cooperation is a driving force in PBL.* Students work on projects in organised groups, where students share knowledge, coordinate activities and decision-making and engage in academic discussions and mutual critical feedback. Furthermore, students engage in close collaboration with supervisors and potential external partners.

- *The problem-based project work of the groups must be exemplary.* The curriculum framework aims to support exemplary learning. Exemplarity means that content, approaches and learning outcomes of projects are transferable to situations students will encounter in their professional careers. The content and outcomes of a project are thus not confined only to the project itself, but are applicable beyond it.

- *The students are responsible for their own learning achievements.* Students have a large degree of freedom to choose projects, thus defining key elements of their education in the AAU PBL curriculum. Meanwhile, students are also responsible for continued individual critical academic self-reflection of their own work and problems in which they engage. A project group is supported by a supervisor who ensures alignment between the curriculum and project work, but the group is responsible for the cooperation, learning process and outcome of a project.

The principles outline many of the principles highlighted in the previous chapters, and likewise afford students opportunities to develop a wide variety of both disciplinary and generic competences. The principles address both practice and formal structuring of engineering students' PBL practice, but local interpretations must be expected (Kolmos et al., 2004). Prompted by the principle relating to students' cooperation in groups, I need to make a slight adjustment in connection to the focus of the thesis: Although Illeris (1978, 1981) uses "gruppe" (group) and Kolmos et al. (2004) use both teams *and* group, in Kolmos and Edström (2014) we only find *team* for students' organisation in projects in PBL. In my view, a 'team', as defined by Katzenbach and Smith (1994), is closer to what we aspire students to become when *collaborating*:

> *A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for*

> *which they hold themselves mutually accountable.* (Katzenbach & Smith, 1994, p. 45)

Dewey (1997a) writes from a societal perspective that any group of people can come together, and even work towards a common end, but only become a community once all are cognisant and interested in the common end and regulate their activities in view of it. I find that to be a fitting description for students working together as well – they are or should at least aspire to be more than a group of people.

THE PBL COMPETENCE FRAMEWORK

Although the AAU PBL model affords students opportunities to develop and reflect on their generic competences, students still struggle when asked to conceptualise their generic competences (Holgaard & Kolmos, 2019). Consequently, assessing competences embedded as enablers which are themselves not easily definable in the first place can be a difficult task – even if critical reflection is a core principle of the AAU PBL model (Aalborg University, 2015) – as PBL practice can become stale or habitual (Holgaard et al., 2021; Kolmos et al., 2021). This has prompted AAU to renew the focus on generic PBL competences and a more progressive integration into the formal curricula. Progressive in this relation is not to be mistaken for progressive pedagogies, but as a temporal perspective to a more continued presence of outcomes relating to PBL.

To facilitate dialogues relating to both curriculum development and aid students' reflective practice, researchers at AAU have aggregated the learning principles of the AAU PBL model into four overall competency areas (see Figure 5): problem-oriented; interpersonal; structural; and cross-cutting meta-competences (Holgaard & Kolmos, 2019). A central and pivotal point for the proposed strategy is an emphasis on participation of programme managers and practitioners, who were tasked with outlining the learning objectives based on the AAU PBL framework. Researchers from the UCPBL centre, where I was employed during my PhD, acted as facilitators for the process as well as support and inspiration for local research communities (Holgaard et al., 2020). In conjunction with the implementation of progressive PBL competences, master's students should – at least in the initial phase – participate in a mandatory workshop regarding their development of PBL competences. The result of the workshop is a one-page PBL competence profile in which students reflect on and articulated their PBL competences (addressed in article 3).

I think it is important to stress that this is not an exhaustive or final list but instead should be considered as a cross-faculty and cross-curricular boundary object residing between social worlds (Star, 2010).

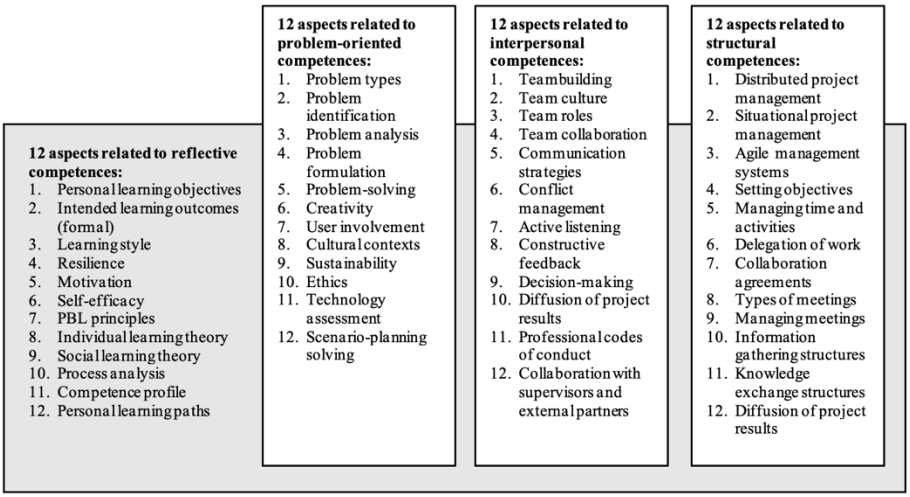

Figure 5. PBL competences (Holgaard & Kolmos, 2021).

A pivotal point with the PBL competence framework is the context. Similarly to the recontextualization of generic engineering competences to a specific profession or scope of shared activities (Male, 2010; Male et al., 2011), PBL competences are a framework intended to initiate and promote students' dialogues and reflections of generic competences developed in and through PBL (Holgaard et al., 2021).

… A BRIEF DISCUSSION ON GENERIC COMPETENCES AND PBL COMPETENCES

The PBL competence framework has predominantly been used as a framework for organising data in two of the three articles. In these articles I do not use the term PBL competences. There are two reasons for this, firstly because I did not know better and secondly for broadening the scope of available literature for the literature review. In my initial reading of definitions of competences and generic competences, I found descriptions of competences to be roughly the same as those in the PBL competence framework (Gonzáles & Wageneer, 2003; Le Deist & Winterton, 2005; Voogt & Roblin, 2012). In what I now consider mandatory early-PhD-fellow overconfidence, I deemed generic competences to be *so* similar to and overlapping with PBL competences to such an extent that these concepts in article II cover the same – and are mostly devoid of context. As I have demonstrated earlier, context is an important part of understanding how competence comes into being (Cannon-Bowers et al., 1995; Raven, 2001). In relation to this, my initial reluctance was also one of contextual application. I felt that using the term PBL competences was part of an institutional effort to take "ownership" of competences described elsewhere and which most likely, at least in my early understanding, could be developed in other pedagogical approaches. As the project progressed and my understanding became more nuanced, I began to consider that PBL competences should be understood as a subcomponent of generic competences tied to a specific pedagogical context, and not one situated on the outside. This, however, entails a further discussion of transferability that I shall return to

later. A final note to this short intermission: for readability and maintaining possibilities for comparison between this text and the included articles, I will use the conceptualisations of competence as they appear in the respective articles.

3.2. RESEARCH DESIGN

To research the conceptualisations of PBL competences from a formalised and institutionalised perspective as intended outcomes and in students' articulations of their experiences in systemic PBL, different representations of learning are explored trough a curriculum inquiry. According to Aoki (2004), multiple perspectives ought to 'increase our vision of whatever we are viewing' (Aoki, 2004, p. 96). Curriculum theory relates to the totality of experience within education[15] (Pinar, 2004), and operates with elements such as different layers of curriculum making, levels of interpretations and interdisciplinary approaches. In conjunction with levels of interpretation there is also a wide variety of potential curriculum orientations based on different tacit philosophies of education (Barnett & Coate, 2005), hidden curricula (Illich, 1972) and even performative aspects (Macfarlane, 2017).

Aoki (2004) outlines three potential orientations for a curriculum inquiry departing from the more usual emphasis on research renditions building on Tyler's (1949) end-means approach to curriculum planning. Instead, Aoki (2004) argues for a fundamental transition from evidence-based research approaches of control to curriculum inquiries, also including first order interpretive and critical perspectives. From a Deweyean perspective, the 'reality' of the PBL curriculum then reveals itself as a result of the activities I (*the organism*) do (Biesta & Burbules, 2003). The orientation of the inquiry also include different ways of being in the world (Aoki, 2004, p. 101):

- Empirical analytical orientation – *man acts upon the world as an object, reality is out there.*
- Situational interpretive perspective – *man-in-his-social-world, reality is intersubjectively constituted.*
- Critical orientation – *man-in-his-world with his world, reality is in praxis (thought and action).*

The empirical analytical orientation is geared towards objectified knowledge and understood in relation to curriculum as an orientation focused on explanatory power regarding cause-and-effect, functional or hypothetico-deductive statements aimed at enhancing efficiency, certainty and predictability. Research applying this orientation is at a distance from the context and primarily consists of second-order generalisations and idealisations removed from those who experience life in the situation the research aims to capture.

[15] And is often misconstrued as a concept dealing only with selection of content and subject matter (Kelly, 2004).

The situational interpretive perspective is oriented towards social situations where being, experiences and meaning construction is manifold and different. Hence, research within this orientation aims towards meaning and communication between humans, and the researcher must provide explanations and interpretations by entering into an intersubjective dialogue with people in the situation.

The third orientation outlined by Aoki (2004) is represented by critical theory and critical reflection aimed at uncovering tacit and hidden assumptions. Here, the researcher becomes a part of the object of inquiry, and questions both subjects and the self. However, reflection is in this vein not only about making the tacit explicit, but

> *is also oriented toward the implications for action guided by the newly gained consciousness and critical knowing. It is interested in bringing about a reorientation through transformation of the assumptions and intentions upon which thought and action rest*. (Aoki, 2004, p. 106)

A critical approach to curriculum inquiry thus transcends the situational life world by including normative structures as well.

A curriculum inquiry can be comprised of several studies each providing different visions of the PBL curriculum. In conjunction to the orientations outlined above, Aoki (2004) describes two distinct frames for an inquiry, *etic* and *emic*, referring to a researcher's position in relation to the field, respectively an outsider observing events and an insider 'who lives within the ongoing flow of lived experiences' (p. 108). In my thesis the stance is etic, as the data consist of representations of the curriculum. The different perspectives of my inquiry into generic competence in PBL curricula are exemplified in Figure 6.

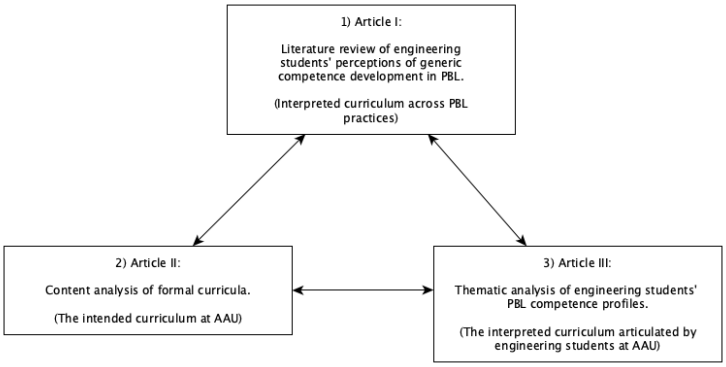

Figure 6. Context, articles and levels of curriculum making.

PERSPECTIVES AND RELATIONS OF THE CURRICULUM INQUIRY

As noted by Aoki (2004), a curriculum inquiry ought to utilize more than perspective, thus affording different visions and possibilities for triangulation. The thesis has three perspectives – one across contexts and two set within the same educational institution:

1. A literature review of generic competences in engineering education.
2. Content analysis of formal curricula focusing on PBL competences.
3. A thematic analysis of students' PBL competence profiles.

The first perspective is a literature review of empirical work researching engineering students' perceptions of generic competence development. The aim of the literature review is to identify rationales for integrating generic competences, methods used to access students' generic competence development and what generic competences are emphasised in existing research. Moreover, the literature review also indicates tacit conceptions of PBL within engineering education research as a pedagogical remedy rather than an educational philosophy. In relation to the thesis, the aim of the literature review is also to subsequently inform a focused unit of both generic competences and methods for the remainder of the thesis.

The second perspective of the inquiry was conducted in parallel with literature review. As part of the cross-faculty research project PBL Future, this perspective was intended to serve as a baseline study potentially informing other subprojects within the research project (see for instance Clausen (2021) for students' development of self-directed learning in PBL and Sørensen (2022) for students' use of digital technologies to orchestrate their teamwork). Here, we conducted a qualitative and theoretically informed content analysis as outlined by Hsieh and Shannon (2005) and Krippendorff (2004) of the formal curricula of 10 bachelor's programmes at AAU to research how generic competences are specified as ILOs, as well as their frequency across semesters. Formal curricula are a central structuring device in the transition from teaching to learning (Adam, 2008; Karseth, 2008), and following this logic, we hypothesise

that explicit ILOs can support students' critical reflective practice in PBL if present in the formal curricula.

The third perspective provided is informed by the results of the literature review, which shows that while teamwork competences are addressed in most included articles, only a few of them provide detailed descriptions of the constituent parts of teamwork competences – in other words, the competences embedded and coordinated in teamwork competences. As I have mentioned before, teamwork is but one example of generic competences, and other competences could also be selected for an analysis of students' experiences. As we have seen, theoretical constructs exist to describe teamwork competences, but our aim was to analyse teamwork from a student perspective. To this end, we performed a qualitative and constructivist thematic analysis of 130 engineering students' PBL competence profiles. The profiles were developed as part of a mandatory workshop intended to facilitate students' reflections of their PBL competences (Holgaard et al., 2021; Holgaard & Kolmos, 2019). In the development of the PBL competence profiles engineering students were asked to reflect on their PBL practice and development of PBL competences and provide descriptions of their experiences of these.

When viewed in combination, the articles provide a potential triangulation of data methods and sources, departing from expectations regarding students' development of generic and PBL competences and moving to the experiences of these in a PBL practice. The literature review provides a perspective of generic competences extending modes of PBL but highlights the expected outcomes of applying a particular pedagogical approach. Much akin to Kuhn's (1970) description of the development of scientific theories, PBL is drawn to the forefront based on potential or anticipated outcomes.

The perspectives are both outside of and inside experienced practice – from a managerial and a student perspective. The classifying expected outcomes are, if following Bloom et al. (1956, p. 12), abstractions of

> *the intended behavior of students – the ways in which individuals are to act, think, or feel as the result of participating in some unit of instruction.*

As mentioned previously, intended outcomes then serve as a structuring device for students' practice, but still provide a framing broad enough to allow for some degree of participant direction (Aalborg University, 2015; Kjersdam & Enemark, 1994). Here, it can be argued that the institutional representation is oriented towards notions of predictability rather than subjective meaning-making based on students' experiences (Aoki, 2004). This is also buttressed by the development of the PBL competence framework which did not involve students as a source of inspiration (Holgaard et al., 2020). It is important to note that while the formal curricula analysed in the content analysis (article II) are from five different faculties, the formal curricula from the educational programmes included in article III have not been analysed in detail. However, a non-structured reading aimed at scoping relevant learning outcomes of the included educational programmes in the third article showed the results of the content

analysis to be exemplary of the educational programmes included in the thematic analysis.

Learning is difficult to capture as students traverse through various steps of encountering new subject matter and accommodating new material and information in their cognitive structure (Moon, 1999, p. 137–151). Forms of representations such as essays or reflective writings allow the student an opportunity to reflect on the relation of experiences and knowledge regarding an aim. Students are required to stand outside of experience to articulate it, both to others and themselves, providing different perspectives on experiences (Dewey, 1997a). Thus, students would engage in a dialogue with an experience, adopting an intentional purpose (Boud et al., 1985). The institutional abstraction of expected outcomes then becomes contextually and experientially situated, providing insights into contexts' activities conducive to the development of PBL competence. In this vein, the results of the thematic analysis could also potentially inform curriculum development by taking students' frames of reference as a starting point for the development of ILOs and pedagogical practices supporting specific competences.

WHAT LANDSCAPE OF GENERIC COMPETENCES UNFOLDS BY REVIEWING EMPIRICAL RESEARCH OF ENGINEERING STUDENTS' PERCEPTIONS OF GENERIC COMPETENCES IN A PBL ENVIRONMENT?

Article I is a literature review of empirical research documenting engineering students' perceptions of generic competence development in PBL (Boelt et al., 2022). While we focus on PBL, we acknowledge that generic competence can potentially be fostered in other pedagogical approaches emphasising authentic project- and teamwork.

The research question guiding the literature review is:

> *What landscape of generic competences unfolds by reviewing empirical research of student perceptions of generic competences in a PBL environment?* (Boelt et al., 2022, p. 1402)

In order to establish an initial understanding of competences and generic competences broad scoping reviews were performed (Booth et al., 2012). Preliminary search results indicated that several nouns are used to describe roughly the same concept, which influenced the selection of keywords in our search protocol. To apply a systematic approach to the searches we followed the process presented in Borrego et al. (2014) and Paré et al. (2016). According to Borrego et al. (2014), a typical strategy for planning and performing a systematic literature review consists of six identifiable steps: identifying scope and research questions; defining inclusion criteria; finding resources; cataloguing sources; critique and appraisal; and synthesis. Following these guidelines, and once our goal was established, we developed a search protocol consisting of relevant keywords and inclusion and exclusion criteria. To make the review manageable, we decided only to include peer-review articles in English.

The searches were performed during July of 2020 and again in November 2021 through EBSCOhost, Scopus and Web of Science using the selected keywords.

Each article was downloaded, including abstract and keywords, and was imported into Mendeley for selection. Figure 7 displays the flow of the information in the literature review.

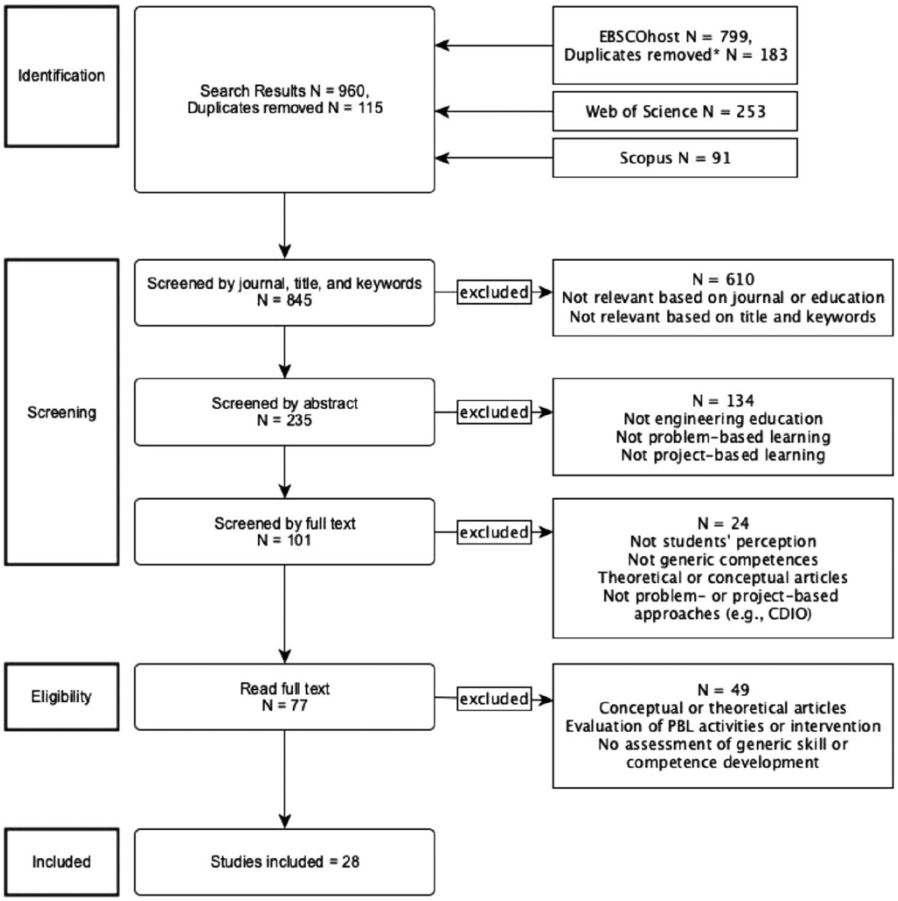

Figure 7. Flow of information (Boelt et al., 2022, p. 1404).

The screening process was primarily undertaken by the first author, discussed with the co-authors and repeated two times to make sure that no article had been excluded by mistake. The process was concluded with the inclusion of 28 articles for synthesis.

The selected articles were coded and categorised in groups corresponding to the competences addressed and methods used to assess students' perceptions of generic competences. In our first draft, the first author coded and categorised the literature into

themes corresponding to the competences addressed in the respective articles. However, we all found such a representation to be too cluttered and disorganised. For readability alone we used the PBL competence framework as a structuring device.

Even though the selection and synthesis of relevant literature were iterated, the selection, categorisation and synthesis of selected articles were primarily completed by the first author. For a greater systematicity all researchers could have coded and categorised articles and compared results in an attempt to mitigate any unconscious bias (Booth et al., 2012; Borrego et al., 2014). However, we aimed to mitigate such bias by timely meetings discussing the process, selection and synthesis of the literature.

HOW ARE GENERIC COMPETENCES FORMULATED AS INTENDED LEARNING OUTCOMES IN THE FORMAL CURRICULA IN SYSTEMIC PBL?

In parallel with working on the literature review, we conducted a directed content analysis of formal curricula at AAU (Boelt et al., 2021). Frameworks describing future competences often emphasise a repositioning of the formal curriculum to ensure the quality and accountability of education (Adam, 2008; Gonzáles & Wageneer, 2003; Voogt & Roblin, 2012). Moreover, some approaches already explicitly state ILO relating to generic competences in formal curricula (Edström & Kolmos, 2014; Kolmos et al., 2021). The research aim of the article is:

> *Explore and examine the prevalence of generic competences in the formal curricula using AAU as an extreme case of systemic PBL integration* (Boelt et al., 2021, p. 134).

The research is part of the cross-faculty research project PBL Future, thus not limited to engineering education. However, we find five educational bachelor's programmes either within or on the periphery of engineering education among the selected programmes. The educational programmes included in this content analysis were already part of ongoing projects by PhD students or senior researchers. The cases selected for the analysis were predetermined by the other projects, and are depicted in Table 1.

Table 1. Educational bachelor's programmes included in the content analysis (Boelt et al., 2021, p. 136).

Faculty	Educational programme (Acronym)	Additional information
Humanities	Communication and Digital Media (CDM) English Studies* (ES)	**Include electoral part of education, teacher training*
Social Sciences	Sociology (SC) Organisational Learning (OL)	
Health	Biomechanical Engineering and Informatics (BIOM) Sports Science (SP)	
Engineering	Nanotechnology (NT) Energy Engineering (EE)	
IT & Design	Medialogy (MED) Internet Technology and Computer Engineering (ITC)	

The analytical approach was based on Krippendorff's (2004) sequential framework for content analysis. Our approach was theoretically informed (Hsieh & Shannon, 2005) and we applied both the Dublin Descriptors (Bologna Working Group on Qualifications Frameworks, 2005), qualifying learning outcomes as either knowledge, skills or competence, and the PBL competence framework (Holgaard & Kolmos, 2019) to categorise relevant ILOs found in the formal curricula in NVivo. The coding tree developed prior to coding the formal curricula is displayed in Figure 8.

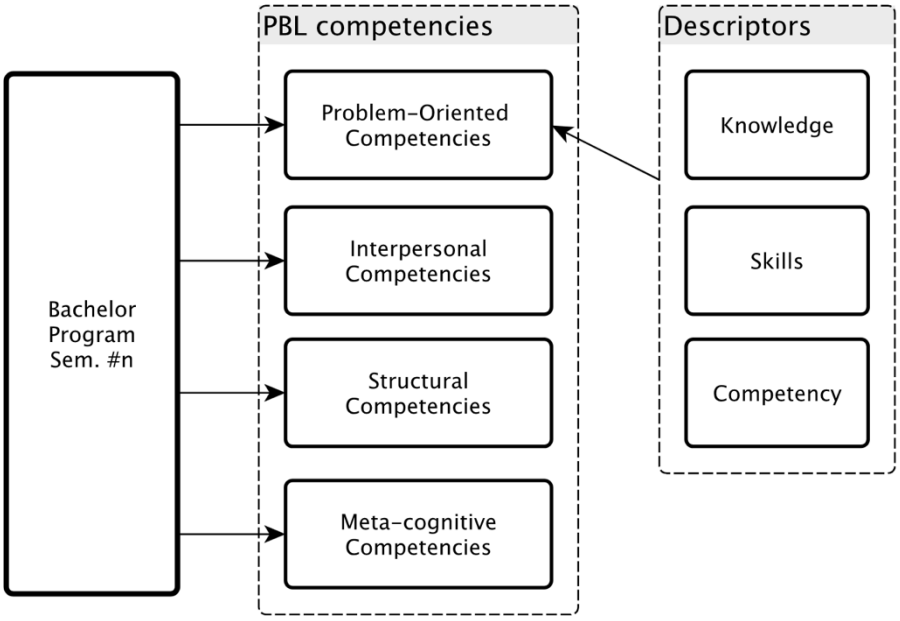

Figure 8. Coding tree for coding and categorisation in NVivo (Boelt et al., 2021, p. 139).

According to Krippendorff (2004), content analysis can be outlined in separate steps, namely:

a) body of text, b) research question, c) context, d) analytical constructs and e) abductive inferences.

The coding was done using *if-else* statements in relation to specific ILOs: If an ILO addressed the development of PBL competences then the ILO was coded and categorised in the corresponding category in NVivo. The coding was done by the first author and discussed with the co-authors and presented to the members of PBL Future for additional comments, suggestions or clarifications concerning the coding process.

The body of text is the formal curricula for the selected educational programmes. According to Krippendorff (2004) and Prior (2003), a text is not just a container, but can be included as allies or enemies in specific contexts. The formal curricula then act as potential structuring devices in a PBL environment where the curricula gain and give meaning (Prior, 2003). According to Prior (2003), documents serve different functions for different actors. For this work we studied a function of anticipated use by students. Implicitly, we thus follow the logic found in the descriptions of ILOs as a supporting structure for student-centred learning (Karseth, 2008; Sarauw, 2011; Steiner-Khamsi,

2009). The tree presented above is, in hindsight, an odd mixture of contextually defined competences and a framework structuring educational reform across Europe (Karseth, 2008; Sarauw, 2011).

HOW CAN ENGINEERING STUDENTS' CONCEPTUALISATIONS OF TEAMWORK COMPETENCES ENRICH THE UNDERSTANDING OF TEAMWORK AS AN ASSET IN CURRICULA DEVELOPMENT?

The focus of article III is based on findings from the literature review, mainly that teamwork and communication were generic competences most often addressed in the literature while being mostly only superficially explained. The aim of the article is to analyse teamwork competences from engineering students' perspectives. Our research question is (Boelt et al., p. 629):

> *How can engineering students' conceptualisations of teamwork competences enrich the understanding of teamwork as an asset in curricula development?*

To answer this question, we analysed 130 engineering students' reflective writings on their PBL competence development using AAU as a critical case of systemic integrated PBL. The competence profiles were developed by students as part of a mandatory three-hour PBL competence workshop aimed at facilitating students' reflective practice on tacit PBL competence development (Holgaard et al., 2021). The outcome of the workshop was a one-page individual competence profile with students' reflections of their PBL practice and competence development. The PBL competence framework was applied as a reflective tool to facilitate students' reflections, which has previously proven to be a difficult task if reflection is unaided (Boud et al., 1985; Riis et al., 2017). To this end, rather than confirming the use of correct nomenclature or quantifying the declaration of specific PBL competences, we chose to focus on students' emphasised experiences of practice.

The collection of PBL competence profiles was discussed with other researchers partaking in other PBL competence workshop to find educational programmes with variations and breadth in students experiences. In addition to this, the authors of this article should not be involved in the PBL competence workshop of the selected educational programme.

Table 2. Departments and educational programmes selected for thematic analysis (Boelt et al., 2023, p. 631).

Department	Educational Programme	Participants
Materials and Production	Operations and Supply Chain Management	43
Electronic Systems	Control and Automation Communication Technology Signal Processing and Acoustics Product and Design Psychology	50
Built Environment	Geography Water and Environmental Engineering Transport Engineering	37

We applied a constructivist thematic analysis for identifying, analysing and reporting patterns across selected qualitative data (Braun & Clarke, 2006; Nowell et al., 2017). The profiles were imported to Atlas TI for coding and aggregation into themes and to provide systematicity and transparency to the process. We followed the six steps outlined by Braun and Clarke (2006) and performed several iterations of refining and defining aggregated themes. Our approach to the thematic analysis was to ensure the breadth of descriptive experiences within specific themes, and not oriented towards quantifying how many times a specific code appeared in a theme.

The first iteration of constructing themes and connections resulted in the mind map displayed in Figure 9. The oval figures are competences at the top level informed by the findings of our literature review (Boelt et al., 2023). The grey and white squares are child nodes on the second and third level – *Relation to peers* is a constituent part of *Mature communication* which contributes to teamwork. *Project management*, *Communication* and *Reflection* are also included as several subthemes supported by a variety of activity. Adhering to the theoretical construct of themes being distinct entities (Braun & Clarke, 2006) proved difficult, as students described interrelations among several themes, suggesting that teamwork competences are fluid in practice. In this relation, students' experiences coincide with previous definitions of competences as entities consisting of timely coordination competences (Cannon-Bowers et al., 1995; Salganik et al., 1999).

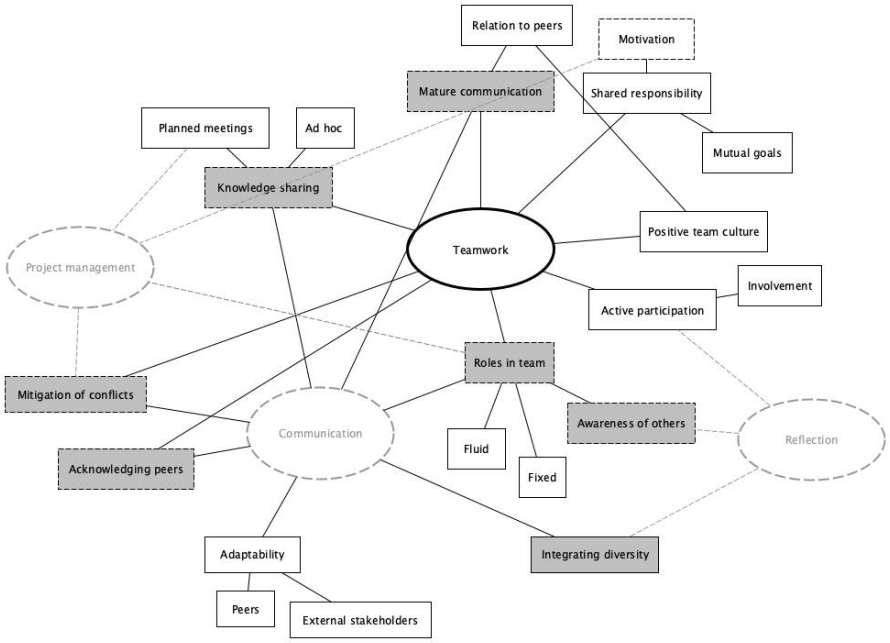

Figure 9. First iteration of construction of themes and connections (Boelt et al., 2023).

For our second iteration we attempted to capture the experiences of students from a temporal perspective inspired by Tuckman's team model (Bonebright, 2010); activities prior to and in performance of teamwork. However, this did not fully capture the fluid teamwork practice described by students, where teamwork and thus needed competences are always negotiated and situationally malleable. Instead, our analysis pointed to a construction of themes in which PBL competences are not confined to specific steps in the students' project work, and are rather part of the evolving and changing practice characterising students' social learning processes.

APPROACH FOR SYNTHESISING THE FINDINGS

As noted by Aoki (2004), a curriculum cannot be fully captured but only approximated by including different perspectives and means of analysis. The included articles forming the basis for the thesis provide different entry points towards the overall research question presented in the introduction.

Previously I have used the metaphor of a *landscape* in relation to the literature review outlined above. In relation to this, I will draw on Dewey's (1902) metaphor of map and explorers as a 'structuring' device for the synthesis. Here, I find it important to stress that Dewey's primary concern in *Child and the Curriculum* was children attending the laboratory school rather than adult students. Still, the notion of maps and

explorers is, in my view, a suitable vantage point for a synthesis of the results. Paraphrasing Polanyi (1972), such a map can reveal the correspondence between the physical map and individual exploration.

Schön (1993) writes of the use of metaphors as a means to reframe problems by using a different conceptual framing. Practically, a map is laid out for students both in terms of themes and potential outcomes, but it is a task for the students to explore the territory outlined by more mature experiences. Thus, we can consider education as more than conservation, but also continuation and growth as described by Dewey (1997a, 1997b), potentially directed by contagious imagination between the involved actors (Whitehead, 1967).

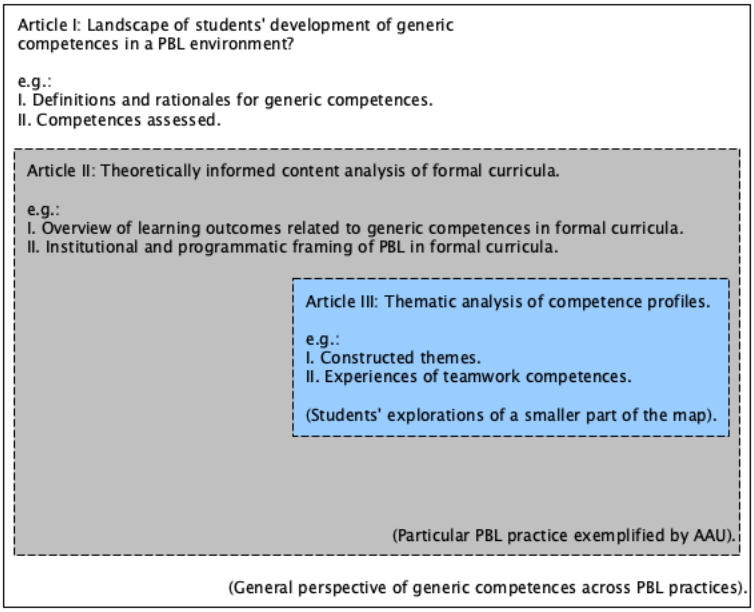

Figure 10. Conceptual map for synthesis of research.

Figure 10 shows a conceptual map of the synthesis with examples of potential foci for the prospective synthesis of findings. I will consider the relation of the articles as being concentric, enabling movement from general to particular and reverse. Articles I and II each provide boundaries for my map. Article I provides contours of PBL practices extending learning activities, framing the research conducted at AAU.[16] As noted, the literature review aims to capture modes of PBL sharing principles with those described by Kolmos and De Graaff (2003, 2013). Article II addresses a section of the map concerning a specific mode of PBL with explicit outcomes related directly

[16] The systemic PBL found at AAU is in this sense just one mode of PBL among an expanding field of variation in implementations, as noted by Savin-Baden (2021).

to the specific practice of PBL. Hence, article III regarding engineering students' articulations of experiences in PBL is situated within the framing provide by the two prior articles and the implementation of PBL at AAU outlined previously. I drawing inspiration from Dewey's experiential continuum, where experiences are connected to one another, and are not disjointed fragments (Dewey, 1978). Similarly, the presented perspectives of the curriculum are in this view considered part of the same continuity covering different conceptualisations of generic and PBL competences. The synthesis also involves a relation to the call for competences in engineering education and the perceived promises of student-centred learning exemplified in PBL outlined in the pages above (see for instance Voogt & Roblin, 2012 and Tahirsylaj & Sundberg, 2020).

CHAPTER 4. SUMMARY AND SYNTHESIS OF FINDINGS

In this chapter I will provide short summaries of the findings of the included articles. Subsequently, I will present a synthesis of the findings applying the approach outlined previously. In article I the focus is on engineering students' perceptions of generic competences across institutional contexts, while articles II and III use AAU as a critical case for systemic integrated PBL. Article II concerns the institutional framing of ILOs related to generic competences in PBL and article III engineering students' conceptualisations of teamwork competences in PBL. The conceptual map displayed in Figure 10 will be updated with central conclusions from each article.

4.1. WHAT LANDSCAPE OF GENERIC COMPETENCES UNFOLDS BY REVIEWING EMPIRICAL RESEARCH OF ENGINEERING STUDENTS' PERCEPTIONS OF GENERIC COMPETENCES IN A PBL ENVIRONMENT?

The literature review reaffirms that PBL is primarily integrated in courses (see Chen et al., 2021). Furthermore, the findings also buttress the notion of competences as a fuzzy concept (Tahirsylaj & Sundberg, 2020; Young & Chapman, 2010), where numerous descriptions aim to capture the same phenomenon; sociotechnical skills, generic skills, soft and transversal skills and generic competences. Generally, the purpose of integrating generic competences were vocational in foci and oriented towards expectations of the labour market.

The findings also show most methods used to assess students' perceptions of their generic competence and skills development were questionnaires using Likert scales administered prior to or after PBL interventions. Other approaches such as analysis of students' logbooks and reflective writing were also found. A single study stood out by using continued assignments for students to explicitly reflect on their 'soft skills' as the point of departure (Ragonis et al., 2020).

Most articles addressed competences such as teamwork, communication, problem-solving, navigating ambiguity and self-directed learning. For readability we organised the competences using the PBL competence framework as a guide: problem-orientation, structural, interpersonal, and metacognitive competences. See Table 3 for categories and subthemes.

Table 3. Categories and themes in included literature.

Category	Included subthemes
Interpersonal competences	Teamwork, communication
Problem-oriented competences	Problem-solving, information retrieval, critical thinking, creativity, systems thinking
Project-oriented competences	Project management, planning, time management
Metacognitive competences	Metacognition, self-directed learning, self-regulation, navigating ambiguity

Figure 11 present categories and themes identified in the included literature. Interpersonal relations were the theme addressed in most of the included articles. Most articles report positive developments in students' perceptions of teamwork competences. However, teamwork is superficially defined, and only a few articles elaborated on the components of teamwork competences using existing research and theoretical frameworks (Murzi et al., 2020; Necchi et al., 2020). Communication was another prominent theme found in the literature review and noted to be an integral part of teamwork. In this sense, communicative competences cover modalities of instrumental communication such as oral and written transmissions to relevant stakeholders (Beagon et al., 2019), but also supporting the psychological constructs needed to support and maintain teamwork, such as mature communication and conflict management (Murzi et al., 2020).

The selected literature also reports a perceived improvement of engineering students' problem-solving competences, which involves collaborative and critical aspects in order to identify, define and solve problems in new and creative ways (Bozic et al., 2018; Mihic & Zavrski, 2017; Zou & Mickleborough, 2015). This is closely connected to retrieval and selection of suitable information applicable for a specified context, diminishing the need for rote learning. Activities are set in collaborative environments, and according to Helmi et al. (2016) problem-solving needs to be understood as a relational competence where the social relations and assets found in the team each contribute to the outcomes of a project.

The literature review also found that a diverse set of project-oriented competences were supported by PBL. Project management involves aspects such as division of tasks when students address authentic problems (Beagon et al., 2019), approaches to formation of teams (Montequin et al., 2013) and generic management competences (Lutsenko, 2018). Overton and Randles (2015) suggest using planned interventions such as 'disturbances' to foster students' project management competences, emphasising that the context and scope of authentic problems often change. Furthermore, it is reported that students engaged in PBL find improvements in individual study behaviour in connection to planning and management due to a shared responsibility (Williams & Handa, 2016).

The last category covers metacognition, self-directed learning and ambiguity. Like the previous categories, PBL is reported to improve students' metacognitive competences. Studies report improvement in students' perceived metacognitive abilities and self-directed learning (Downing et al., 2011; Lutsenko, 2018). In addition to this, studies also show that students perceive improvements in competences related to navigating ambiguity and in students' tolerance of ambiguity and uncertainty (Bozic et al., 2018; Moliner et al., 2015).

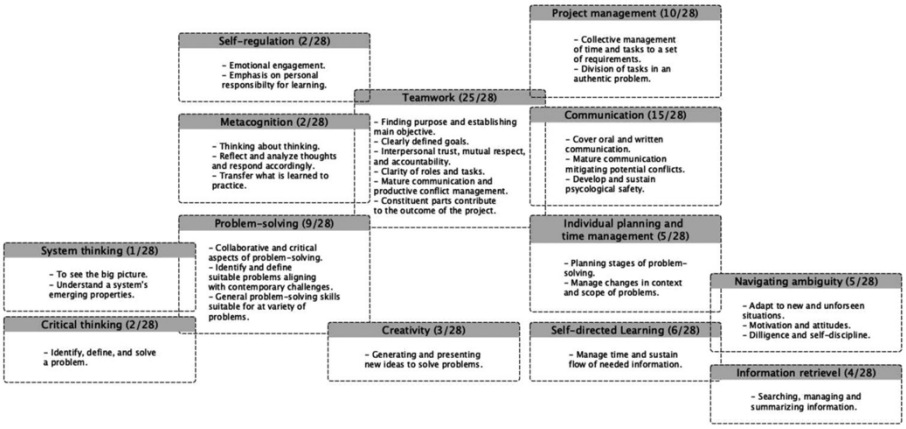

Figure 11. Themes and components of included literature (Boelt et al., 2023, p. 1415).

The literature review finds that there is a positive relation between PBL and students' perceptions of generic competence development. Most articles address teamwork while the remaining subthemes are less prominent. We find this to coincide with characterisations of engineering practice as a social endeavour rather than solitary problem-solving (Jonassen et al., 2006; Siller et al., 2021). Still, constructs such as teamwork and communication are mostly addressed superficially, and only a few articles describe the constituent parts. To this end, we suggest paying more careful attention to the specific constructs and their parts.

4.2. HOW ARE GENERIC COMPETENCES FORMULATED AS INTENDED LEARNING OUTCOMES IN THE FORMAL CURRICULA IN SYSTEMIC PBL?

The directed content analysis of formal curricula shows that the vast majority of ILOs relating to PBL competences are located in the first semester. While this was the case for all bachelor's programmes, great variation concerning the prevalence of ILOs between the programmes were outlined (Boelt et al., 2021).

During the first semester most students participate in an introductory PBL course preparing for further study at AAU. Here, the content address different PBL models and practices which includes strategies for problem-solving, work processes, organisation of teamwork and conflict management, to name a few subjects. This is reflected in the

formal curricula for most educational programmes, where the introductory course also carries the bulk of ILOs related to PBL competences. After the first semester the prevalence of ILOs related to PBL competences diminishes, and only appears sporadically in the rest of the semesters.

Following the logic of accountability and transparency of learning outcomes (Biggs, 1999; Karseth, 2008; Marope, 2017), there is a risk that students' PBL practice can become increasingly tacit and informal if consecutive semester projects follow the same structure and process – and even outcomes. To this end, we speculate that students' PBL practice can potentially become inarticulate and un-reflected knowledge-in-action (Polanyi, 1972; Schön, 1983). Articulating knowledge would in this sense for students result in a process of 'externalisation' where the articulation will allow for critical assessment and reflection (Polanyi, 1972).

From a formal level, we speculate that supervisors become the primary resource of theoretical reflections concerning students' PBL practice unless students pursue those activities themselves. To this end, we suggest supporting students with theories relating to PBL competences such as collaboration and project management. Consequently, ILOs related to PBL competences should be more integrated in the formal curricula as expected outcomes of students' PBL practice. Furthermore, previous research has shown that students and staff have different interpretive frameworks (Brooman et al., 2015; Erikson & Erikson, 2018), thus we recommend including students' perspectives when ILOs are developed and integrated to ensure not only alignment of curricular objectives but also mental models.

4.3. HOW CAN ENGINEERING STUDENTS' CONCEPTUALISATIONS OF TEAMWORK COMPETENCES ENRICH THE UNDERSTANDING OF TEAMWORK AS AN ASSET IN CURRICULA DEVELOPMENT?

The thematic analysis resulted in the construction of five themes, one of which derives from Cannon-Bowers et al. (1995), based on experiences described in engineering students' PBL competences profiles. Although our analysis focused on teamwork, we found that other themes also support teamwork. Project management is one such instance, and some students emphasised that timely management of tasks enabled both transparency and foresight, thus mitigating potential conflicts related to or caused by task allocation. The themes are as follows:

- Finding complementary competences.
- Establishing teamwork culture.
- Preventing and managing conflicts.
- Awareness of self and others.
- Shared situational awareness (Cannon-Bowers et al., 1995).

Each of the themes can be elaborated with further detail by including components emphasised by students and exemplified by excerpts found in the PBL competence profiles. In Table 4 themes and components are synthesised.

Table 4. Summary of competences and components emphasised by engineering students (Boelt et al., 2023, p. 633).

Theme	Components emphasised by students
Finding complementary competences	Competence clarification Defining roles Alignment of expectations* Attentive to personal differences in experience and skills Task allocation Establishing rules and guidelines for teamwork
Establishing and maintaining a culture supporting teamwork	Creating a comfortable work environment Open communication Constructive feedback Differentiation based on personality
Preventing and managing conflicts	Acknowledging peers' perspectives Understanding peers' perspectives Alignment of expectations* Regular meetings (part of project management) Potential for collective and personal growth
Awareness of self and others	Reflexivity Analytical view on differences in personality Critical review of work Multicultural awareness Participation
Shared situational awareness	Formal and informal communication Redistribution of tasks Knowledge sharing Observing and identifying team members' individual strengths Ad hoc role adjustments

The engineering students emphasise experiences of finding complementary competences and clarifying expectations prior to engaging in teamwork. For the students this implies an attentiveness to team members' different experiences, expectations and skills when a project is broken into smaller tasks. Students highlight that assigning tasks to 'the right people' influences the efficiency of teamwork. Some students also emphasise the importance of diverse personalities and skills to create synergy in a group.

Establishing and maintaining a supportive culture for teamwork involves activities to create the psychological constructs stressed by Borrego et al. (2013), such as mature communication and constructive feedback. Collaboration with peers is necessary for

students to develop competences needed to maintain a productive team culture. Furthermore, students highlight that collaborating has provided a nuanced view of how people work as well as experiences to enable the needed conditions for such work.

The previous themes show students' experiences of establishing and maintaining teamwork. While preventing and managing conflicts can be considered in the initial phases of forming a team, students' PBL competence profiles point to conflicts as emergent and handled ad hoc. Students highlight that conflict should be handle timely and thoroughly by making sure everybody is heard. In connection to this, students also point to weekly meetings to mitigate conflicts, thus emphasising the relation between project management and conflict management.

The theme *awareness of self and others* was constructed on the basis that students often position themselves in relation to peers in an attempt to show *uniqueness-as-difference* (Biesta, 2013). However, students are also aware of when the individual uniqueness in specific situations needs to change as changing conditions require a different set of competences. Here we also find experiences describing a shared responsibility among team members where adaptability to situations and reflection on self and others mean that predefined positions are malleable and flexible.

Shared situational awareness concerns activities that enable engineering students to become aware of the progression of a project. To this end different means of communication and semantic resources are applied to develop a mutual understanding among the students. Students emphasise weekly meetings as a space for discussing and sharing knowledge and making informed decisions concerning the respective project thus making the team more resilient. This also enables the team to respond appropriately to new information or emerging impediments.

The thematic analysis of engineering students' PBL competence profiles resulted in the construction of five themes, each one emphasising coordination of different components to establish and maintain fruitful teamwork. The results also indicate that engineering students in PBL consider reflexivity as important when collaborating with peers, and in relation to tasks and teamwork. Furthermore, we find a collective orientation to teamwork (Cannon-Bowers et al., 1995), involving both personal attitudes and competences enabling peers to perform effective teamwork. The findings can be used pedagogically to plan interventions catering to specific components presented in Table 4. Inspired by Overton and Randles (2015), we suggest that planned interventions altering the course and content of engineering students' projects can promote situations requiring students to adapt and reframe parts of a project. This could exemplify development of shared situational awareness.

4.4. SYNTHESIS OF FINDINGS

In the following I will provide a synthesis of the conducted research in relation to the general research question of the thesis:

How are generic and PBL competences conceptualised from a formalised and institutionalised perspective as intended outcomes, and how do they correspond in students' articulations of their experiences in a PBL curriculum?

Findings from the individual articles are summarised in Figure 12, which also depicts a conceptualisation of the articles' relations and embeddedness.

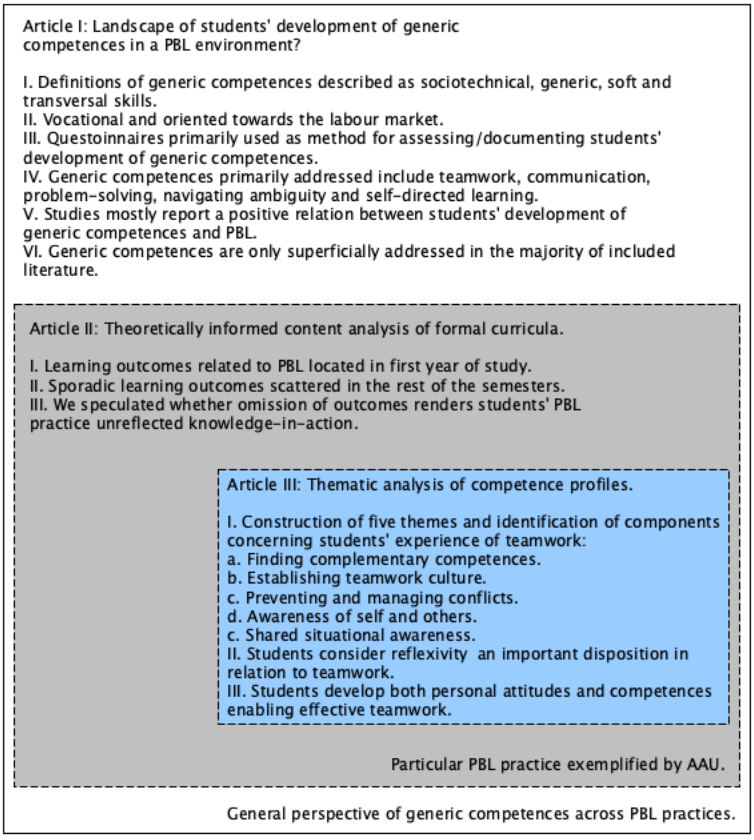

Figure 12. Central conclusion and foci from the conducted research.

As I have hopefully demonstrated in the first two chapters of the thesis, the university as an institution is situated within a larger ecology consisting of a myriad of educational aspirations and perceived purposes depending on the specific vantage point –

be it economic, cultural, personal or the natural environment (see for instance Barnett, 2017), converging in a "rainbow-coalition" of internal conflicts (Krejsler, 2004).[17]

The last two decades' focus on competence development has in many ways been foreshadowed by Illeris' (1978, 1981) suggestion for an alternative Didaktik emphasising applicable knowledge rather than 'backward conceptions of Bildung and liberal education'. With the increased focus on education as a vehicle for economic growth it is not surprising that educational institutions respond in one way or another by means of different pedagogical approaches. This is also noted by both Male (2010) and Voogt and Roblin (2012), who find student-centred learning approaches among the most viable options for catering to students' development of either generic engineering competences or 21st century skills. However, the responses are to external factors influencing internal educational practices, and to this end it can be asked why the student perspective on individual generic competence development is important at all? Another way of posing this question might be to ask whose map we are referring to. Here, I will draw on the idea of outcomes as a means for transparency and guidance promoted by Dewey (1902) rather than fixed ends.

The arguments for focusing on generic competences was in the literature review found to be mostly vocationally orientated (Boelt et al., 2022), and PBL suggested as a pedagogical solution or tool. This inclination also seems to be fruitful as engineering students in the included studies report a positive development in the specific generic competences in focus. The literature review includes a variety of PBL modes, mostly as course-based interventions, and as such the PBL interventions are less formalised and institutionalised than the educational context framing of systemic PBL in the two other articles included in this thesis. Moreover, the literature review also shows that only a few articles unpacked specific generic competences in constituent parts (see Murzi et al., 2020; Necchi et al., 2020). Thus, the PBL competence framework and guide proposed by Holgaard et al. (2021) can serve as a viable entry for a richer picture of competence development within a specific form of PBL. In conjunction with this, the methodology and results presented in Boelt et al. (2023) provide the students' perspective when applying the framework to their own experiences in PBL.

The institutional framing of generic and PBL competences as learning outcomes are unsurprisingly less detailed than the descriptions provided by students in the thematic analysis (Boelt et al., 2023). Zooming in on learning outcomes related to teamwork (interpersonal competences) in the formal curriculum (Boelt et al., 2021, p. 141–145) and the PBL competences framework (Holgaard & Kolmos, 2019) also shows less detailed descriptions and categories such as the following:

[17] While I was participating in a PhD course, a lecturer said that he was interested in how I would separate the policy from the education. So far, I have made no clear delineation of the two as distinct spheres but have outlined how education has historically been influenced by different actors promoting different agendas.

- *Analyse and reflect on causes and potential solutions to potential conflicts within the group*
- *Collaborate with others to develop and optimise situations for learning on an individual, group and organisational level*
- *Plan, structure, and manage a project*

as well as teambuilding, team culture and conflict prevention and management (to name a few).

In this vein, it must be noted that Holgaard et al. (2021) provide ample examples of how competence in teambuilding may unfold, and that the first initial overview is just that – an overview of potential focal areas for further exploration and reflection. In the thematic analysis it is clear that engineering students' experiences of PBL competences are much richer and plentiful than what can, and perhaps should, be captured as outcomes. Rather, experiences deemed conducive to generic and PBL competence development by engineering students can serve as potential starting points for pedagogical interventions. However, the learning outcomes identified in our content analysis projects a territory laid out by more mature experiences, to paraphrase Dewey (1902), but it is a task for the students to explore the map as they engage in a participatory PBL practice extending throughout the entire semester at AAU. If we follow the logic of learning outcomes described by Adam (2008) then outcomes serve not only as means for accountability, but also transparency regarding the intention of a process. Thus, learning outcomes can in this way act as means for reflection during the process. However, students' use of learning outcomes is not within the scope of this thesis.

A critical dimension emerges when looking over the included articles, which is the notion of transparency and opportunities for reflective practice. In the literature review, students' reflections of development of generic competences are primarily prompted by using quantitative questionaries rather than qualitative methods such as the one proposed by Holgaard et al. (2021) and analysed in our thematic analysis (Boelt et al., 2023). Noticing and becoming aware of sensory impressions is the first step in making tacit knowledge conscious (Moon, 1999). While the various methods reported in the literature review indicate different reflective practices of different magnitudes and pedagogical scaffolding, students must still undertake some self-assessment in relation to a task and context to assess their competence development. While quantitative questionnaires do not entail articulations in a move to the outside of experience as proposed by Dewey (1997a), it may be a first step in *noticing* and subsequently prompting reflection. Still, a qualitative reflective practicum appears to shed light to the experiences and situations supporting the development of generic and PBL competences, offering a glimpse of specific waves sailed by students in the sea of teamwork. Developing curricula involves thus not only relevant learning outcomes, framings of student responsibility or adhering to specific learning principles, but also pedagogical activities facilitating and scaffolding reflection, as noted by Boud, Keogh and Walker (1985) and Riis et al. (2017). Even though PBL competences, and thus

derived generic and employability competences, are explicitly stated in formal curricula at AAU (Kolmos et al., 2021), the analysis shows the major bulk of learning outcomes related to PBL are found in the first year of study. The formal curricula ILOs related to PBL are quickly omitted, potentially rendering practice informal and tacit, or even stale. According to Marope (2017) and Adams (2008), the curriculum and learning outcomes play a pivotal role in the transition from teaching to learning. It is, however, not clear what effect explicit outcomes has on students' learning, and research paints a rather ambiguous picture of learning outcomes (Brooks et al., 2014; Havnes & Prøitz, 2015). However, the added transparency of expected outcomes can provide students an opportunity to reflect on what they have to be able to demonstrate once a learning process is at an 'end'.

CHAPTER 5. CONCLUSION AND DISCUSSION

I will in this chapter conclude and discuss the research presented in this thesis and elaborate on the implications for understanding students' competence development. The research has addressed the overall research question below by researching three different perspectives on generic and PBL competences development in engineering education:

How are generic and PBL competences conceptualised from a formalised and institutionalised perspective as intended outcomes, and how do they correspond in students' articulations of their experiences in a PBL curriculum?

The three articles included in the thesis have by different means researched conceptualisations of intended and experienced PBL competences across contexts and in systemic PBL from three perspectives:

1. A literature review of generic competences in engineering education.
2. Content analysis of formal curricula focusing on PBL competences.
3. Thematic analysis of students' PBL competence profiles.

Each article applies various methods to research how generic and PBL competences are conceptualised across and within institutional contexts and in students' articulated experiences. Overall, the results of this thesis show engineering students experiencing a variation of PBL perceive their generic and PBL competences to develop. This holds for both the synthesis provided in our literature review extending across contexts (Boelt et al., 2022) and the results from the thematic analysis of competence profiles (Boelt et al., 2023). While our content analysis revealed the formulations of explicit learning outcomes related to PBL competences as rather general and fragmented (Boelt et al., 2021), the thematic analysis of engineering students' competence profiles depicted variations of richer experiences of generic and PBL competence development in teamwork than documented as explicit learning outcomes. This is as such not surprising, as too detailed learning outcomes may be a hindrance to exploration in a Deweyan sense, and act as fixed ends rather than a potential guide. However, in the institutionally applied principles for PBL AAU emphasises that students are responsible for reflecting on their learning, and in this light it can potentially be problematic for students if learning outcomes related to PBL competences are few and scattered.

The literature review indicates that PBL is mostly depicted as a tool or instrument to meet certain ends, such as generic competence development, with little regard to the perspectives on student autonomy and participant direction found in Illeris' (1978, 1981) early rendition. While exemplary and authentic problems may promote a sense

of professional ways of doing, the thematic analysis shows engineering students developing various personal dispositions to conduct teamwork, such as collective orientation, shared situational awareness and increased reflexivity to team members. Thus, PBL seems to also support the development of personal dispositions and attitudes that act as enablers of other generic competences.

From a general and cross-institutional perspective the literature review indicates that only few articles elaborate on the generic competence assessed (Boelt et al., 2022). In other words, there is a need for careful attention to applications of concepts such as competence that has elsewhere been defined as "fuzzy" (Le Deist & Winterton, 2004) and "ideological" (Tahirsylaj & Sundberg, 2021). Here, the PBL competence framework offers an attempt to capture and elaborate on the constituting parts of specific competences related to a particular context to initiate students' reflections. Students' experiences can then not only contribute to the development of learning outcomes, but also qualify generic competence models such as the PBL competence framework or others reaching across educational institutions.

5.1. GENERIC COMPETENCES AND ACTIVE LEARNING

The literature review outlined rationales for transitioning to PBL, but theoretical conceptualisation of the components of specific generic competences were not identified, except for in a few articles. Still, the need for engineering students' development of generic competences was generally depicted in similar ways: factors such as emerging technologies, lifelong learning and gaps between education and industry (Beagon, Niall & Ní Fhloinn 2019; Božić et al. 2018; Kadir et al. 2016). As demonstrated above, timely responses to changes in society and in means of production were also outlined by Illeris in the 1970s (Illeris, 1978) as an argument for something different than what Freire (2017) called banking education. In a similar vein as Illeris' 1978 writings, the arguments for applying PBL to develop students' generic competences is also occupational in foci, and oriented towards employability (Kolmos, Holgaard & Riise, 2021). However, the literature review also revealed an instrumental and behavioural conception of PBL where the expected outcomes of the entirety of the learning process were anticipated in advance, with an emphasis on potential competences rather than democratic participation where

> *inquiry is reduced to little more than an "active learning" strategy (Lee, 2012, p. 6) that is deployed to ensure students will be more likely to recall, reproduce, and mentally manipulate predetermined academic content (i.e. "enhanced" learning) (Prince & Felder, 2006). As such, Dewey's vision for liberating, humanizing education is turned into yet another kind of uncritical pedagogy that indoctrinates students into pre-existent social practices (Garrison, 1998, p. 114).* (Stoller, 2018)

In my reading and philosophical inclination, there is a risk of PBL being reduced to a pedagogical instrument or tool used towards predefined outcomes rather than a pedagogical philosophy – however eclectic the theoretical backbone may be – if an implementation is geared towards potential competences alone. However, the thematic analysis shed some light on the students' experiences in systemic PBL regarding competence development. In conjunction with functional competences enabling a fruitful PBL practice, engineering students also display an attentiveness towards peers developing as part of a collective orientation towards teamwork. This attentiveness mostly appears in the themes 'awareness of self and others' and 'shared situational awareness' (Boelt et al., 2023). Further, I will argue that the constructed themes require students to engage in various projects to experience studying and working in different teams and with peers. In line with the descriptions of PBL competences by Holgaard et al. (2021), generic and PBL competences cannot be experienced or developed without engaging in a PBL practice of continued experimentation and exposure to others. Thus, engineering practitioners embracing and implementing PBL for the purpose of generic and PBL competence development need to be mindful that results may vary depending on the framing and classification of subject matter (Boelt et al., 2020). Moreover, from the thematic analysis it is clear that PBL not only contributes to competence development but also to personal traits such as increased reflexivity and acknowledging peers' opinions. Paraphrasing Passow and Passow (2017, *original quote found on p. 14*), the interrelationships among PBL competence extend beyond the inseparability of technical, collaborative activities and personal dispositions.

5.2. DISCUSSION OF RESULTS

Though the review found a positive relation between PBL and students' perceptions of generic competences development, it also showed that generic competences are only superficially addressed. Furthermore, generic competences were often hinged on other evaluations and not as such a primary focus for many articles. This was a bit surprising as generic competences have previously been conceptualised as enablers of professional practice, thus directly embedded in the professional identity of engineers (Trevelyan, 2010; Woollacott, 2009).

The literature review focussed exclusively on the formalised educational setting and overarching framework of PBL, and in this way we are potentially blind to competence developments occurring in other places possibly influencing students participating and evaluating a PBL intervention. It might be expected that other activities and educational approaches emphasising problem-orientation and project-organisation as central principles will yield similar results. Still, the literature review documents a positive relation between engineering students' perceptions of generic competence development and PBL. However, as Burbules and Biesta (2003) remark, an inquiry is also characterised by temporal perspectives and thus change over time. Hence, the definition of competence outlined in chapter 2.2 was developed after the review, and the emphasis on activities as central to competence in situ was not part of the literature review. Including activities might afford opportunities for more detailed comparison between variations of PBL.

The directed content analysis shows that the bulk of ILOs relating to PBL were found in the first semester and only a few fragments across the remaining semester. This finding shows that the cross curricular PBL competences are mostly related to specific introductory courses as ILOs but are implicit elsewhere. In concord with the literature emphasising learning outcomes as central mechanisms in adding transparency to students in the guise of outcomes (Adam, 2008; Karseth, 2008; Sarauw, 2011), we speculate whether the lack of ILOs concerning PBL can potentially influence students' PBL practice.

Here, we find the reflections of activities as ILOs predefined for students to offer transparency regarding expected outcomes. Our argument presupposes that there is an alignment of the logic of ILOs presented by theorists such as Tyler (1949) and Biggs (1999) and the ways in which the documents are used in practice by students. To ascertain whether such alignment exists will require more research. Furthermore, the categorisation of PBL competences using the Dublin Descriptors is, in hindsight, a bit limited in terms of conceptualisation. As a supplement we could have used Bloom et al.'s (1956) taxonomy to make a more detailed analysis by including the active verbs denoting class and hierarchy of outcomes. Such an approach would align more closely with the rest of the thesis, emphasising attentiveness to the constituent parts in coordination of specific competences. Bloom et al.'s (1956) gestalt view could have served as an inspiration for this dimension earlier in the research. However, it can also be argued that an increased application of ILOs is antithetical to the experiential learning based on Dewey, as potential ends in view emerge from activities and the context of an inquiry, and cannot be easily defined prior to it (Stoller, 2015; Dewey 2008a).

The focus of article III is based on the findings of the literature review. Initially, my focus was on all four PBL competence domains as a general concept, but during the process of reviewing the literature it became clear that an orientation towards a specific competence was necessary, and as teamwork was the most prominent theme, though still ill-defined, it piqued my interest. It was surprising, and annoyingly banal, to find communication as a theme and competence running across all constructed themes from the engineering students' competence profiles. However, this supports the notion by Trevelyan (2010), highlighting that engineering very often and for extended periods of time requires dialogue with a diverse field of actors. Consequently, the findings also buttress the findings from the literature review, mainly that competences need to be understood as the coordination of parts and ought to be pedagogically framed as such. For curriculum development, this finding also points to a different framing of tools and methods for planning, conflict management and so on, to one of communicative practices in which semiotic resources give and get meaning. Much akin to Dewey's (1997a, 2008) rejection of the dichotomy of theory and practice, planning and management is another type of communication ensuring that students are "*cognizant of the common end and all interested in it so that they regulated their specific activity in view of it*" (Dewey, 1997a, p. 5).

It was previously noted that ideas of social efficiency and human capital theory are implicit in definitions of competences used in education (Tahirsylaj & Sundberg, 2020), but are also found in suggestions for changing higher education (Gibbons et al., 2012). I find it worrisome that most of the articles in our literature review overwhelmingly portray an instrumental approach to the application of PBL as a tool to develop competences with little critical reflection – and with little attention to student empowerment and autonomy. One of the major caveats of traditional teaching is the imposition of values and ideology (Freire, 2017), but one can speculate whether student-centred pedagogies have been subsumed into the values of capitalist society, and now through concepts such as employability and entrepreneurship impose implicit values and ideologies on students. For empowering education, educators both need to support students in their professional development, but also make students aware of any implicit ideological values informing the trajectory of education – to this end Illeris' (1981) concept of double qualification seems to be relevant. Though educational institutions need to comply, or at least acknowledge, stakeholders' aspirations and expectations of graduates, responding to what is required now might just perpetuate what already exists:

> *Any scheme for vocational education which takes its point of departure from the industrial régime that now exist, is likely to assume and to perpetuate its division and weaknesses, and thus to become an instrument in accomplishing the feudal dogma of social predestination.* (Dewey, 1997a, p. 318)

Even with the spread of PBL as learning approach (Chen et al., 2021), the gap between the labour market and education persists (Male et al., 2011a; Trevelyan, 2010), and is mostly addressed by practitioners (Male, 2010; Woollacott, 2009). Metaphorically (and literally), a gap has more than one side, but often the gap is addressed from an occupational perspective rather than from a student perspective, and is often followed by arguments for increasing collaboration with professional practice (Tymon, 2013). Gewirtz and Paretti (2021) find that becoming a professional practitioner in engineering is a complex interrelation of tasks, structure, agency and liminality, and not one limited to catering to specific competences in engineering education alone. Given that engineers work in interdisciplinary domains, developing teamwork and communicative competences are needed to engage productively and considerately in practice (Borrego et al., 2013; Passow & Passow, 2017; Trevelyan, 2010). As we saw earlier, for students to critically reflect on generic competences, developmental knowledge of the constituent parts of a particular competence is needed (Necchi et al., 2020; Ragonis et al., 2020).

5.3. CONTRIBUTION TO ENGINEERING EDUCATION

Exploring engineering students' development of generic and PBL competences has resulted in two contributions to research in engineering education.

The literature review explored students' generic competence development in PBL. This resulted in a landscape of competency domains and methods used to assess students' perceptions of generic competence development. While the research in many ways reaffirms what was expected, and what has previously been found for PBL in general as well as PBL in engineering education (Berthelsen et al., 1996; Kolmos et al., 2021), I find the primary contributions to lie elsewhere. The overview of methods used for self-assessment was mostly based in quantitative approaches which indeed can be useful to test aspects such as students' self-directed learning (see for instance Clausen, 2021), but such approaches do not capture students' qualitative experiences of generic competence development. Furthermore, we find most of the articles only superficially outline theories and constructs of what a competence is the resulting coordination of. Borrego et al. (2013) address a similar point:

> *This superficial use of I/O psychology literature by engineering and computer science faculty underscores the need for collaboration by engineering faculty with those trained in relevant disciplines to access the literature and theories that will advance training of engineering students in teamwork.* (Borrego et al, 2013, p. 498)

The first contribution is modest, and points to increased attentiveness to the constituent parts of competences assessed by researchers, including students' relation to tasks, contexts and external requirements.

Engaging engineering students in reflective explorations of their generic competence development can provide additional details to conducive activities and experiences applicable for pedagogical scaffolding and support. A participant perspective could provide context to qualify generic and PBL competences as experienced. These can be exemplified as potential outcomes or ends in view or be used as part of a pedagogical device informed by students' reflections.

Furthermore, while the study points to the social learning aspect of PBL as pivotal in developing engineering students' teamwork competences, it must be added that the social practice can still become stale and habitual (Schön, 1983). Hence, project-organisation ought to be supported by reflective opportunities for students to take notice of their tacit knowledge.

5.4. LIMITATIONS AND FUTURE RESEARCH

This thesis only includes students' perceptions of their generic and PBL competences development as reflections of learning. The research context of the thesis is primarily AAU, and the PBL competences framework developed at AAU is a recurring frame for analysis and structure.

The literature review focused only on peer-reviewed articles even though Tahirsylaj and Sundberg (2020) conclude that the vast majority of articles concerning compe-

tence development are grey papers often from policy development with no peer-review process. Moreover, the authors find these papers to be enrolled uncritically in educational discourse. An inclusion of grey papers may then have provided additional information relating to the policy nexus of curriculum making.

The exploration of engineering students' development of generic and PBL competences primarily involves students' reflections of practice. Paraphrasing Polanyi (1972), the reflections are abstractions we have no way of testing by comparing them to a physical landscape of actual practice. In other words, we must believe students' subjective statements to be true. Still, between a literature review and 130 PBL competences, similar experiences and results occur. In this relation, the analysis of formal curricula mirror what students are expected to learn – not necessarily what they do learn (Erikson & Erikson, 2018; Hussey & Smith, 2002) – or whether students' reflections of experience actually imply intelligent action in a Deweyan sense (Dewey, 2008). Moreover, inclusion of supervisor and other staff perspectives on engineering students' practices and activities may serve as our physical landscape where we compare students' abstractions to concrete reality of situated practice.

The second contribution aligns with the interdisciplinary aspirations by Borrego et al. (2013). If generic competences are embedded as enablers of competences, we can hypothesis that they act as coordinating mechanisms. As engineering students are on the path to be initiated into the mystery of the discipline, knowing more about less (Bernstein, 1996), outsiders to engineering education and professional practice might have a different perspective from which to observe competences that are embedded in practice. To this end, and as some of the definitions of competence are highly functionalistic (Le Deist & Winterton, 2005; Rychen & Salganik, 2003a), observations of students' PBL competences in situ would shed more light on how these enable and are embedded in students' practices, and if some are embodied to a point of becoming tacit.

Furthermore, I suggest additional research be conducted in relation to students' entry into the labour market. The infamous gap seems to endure and involving graduates in research concerning the transition could provide new insights into how authentic academic knowledge and epistemological cultures are translated once they meet "real-world" practice. I am curious if what is measured in the included research synthesised in our literature review (Boelt et al., 2022) is the effect of students being exposed to a new or different pedagogical approach, or if it is the actual results of the PBL intervention.

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