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BY
NICOLAJ RIISE CLAUSEN

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AALBORG UNIVERSITY
DENMARK

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A Study of Self-Direction in the Aalborg PBL Model

by

Nicolaj Riise Clausen

AALBORG UNIVERSITY
DENMARK

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PhD supervisor: Professor Anette Kolmos
Aalborg University

Assistant PhD supervisor: Associate Professor Claus D. Hansen
Aalborg University

PhD committee: Associate Professor Lars Birch Andreasen (chair)
Aalborg University, Denmark

Professor Jonte Bernhard
Linköping University, Sweden

Professor Woei Hung
University of North Dakota, USA

PhD Series: Technical Faculty of IT and Design, Aalborg University

Department: Department of Sustainability and Planning

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CV

My name in Nicolaj Riise Clausen 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) at Aalborg University. I have a Master of Science in Sociology from Aalborg University, completed in 2015. Before starting my PhD studies, I worked as a research assistant at UCPBL as I have also done in between working on my dissertation. My PhD dissertation is a part of the cross-faculty PBL Future Project where I also contributed to various efforts, in particular focused on establishing a baseline study of student and staff perceptions about AAU PBL. My current research interests include problem-based learning, self-directed learning, quantitative methods, technology in learning, and engineering education.

ENGLISH SUMMARY

Many present-day visions for the future of education emphasize the necessity of pedagogical approaches that foster adaptability to evolving competence demands and therefore advocate self-directed learning (SDL). Problem-based learning (PBL) is often heralded as an effective means to enhance SDL, with evidence suggesting that it improves students' autonomous learning, metacognitive regulation, critical thinking, self-reliance, readiness for SDL, and research skills. Central to all models of PBL is the role of student agency in the learning process, a principle consistently applied across different PBL implementations to engender intrinsic motivation. However, the effectiveness of PBL in promoting SDL is not conclusively established, with some studies challenging the strength of this connection.

One possible source of the inconclusive results may arise from the diverse implementations of PBL, and the various ways SDL has been conceptualized and assessed. The different implementations and incorporation of PBL across various disciplines, initially in health and later in other fields, has led to a variety of models and practices, highlighting the need for greater scrutiny of the applications and transparency of research into PBL. Previous research has indicated a link between PBL and SDL but has primarily been conducted within case-based approaches in medical education. This study, however, researches SDL in a broader range of disciplines and educational programs within Aalborg University's problem- and project-based model of PBL which is implemented systemically across all educational programs.

This PhD thesis sets out to study the development and practices of SDL among students at Aalborg University. The research is disseminated primarily through three articles, and the study was conducted in four phases. The first phase, presented in chapter 2, shares a historical overview that aims to frame the subsequent studies through an exploration of the contemporary assumptions about learning, the seminal studies that defined and delimited SDL, and the prevailing understandings of, and debates about, SDL and its relationship to PBL. The subsequent three phases each comprise a chapter in the thesis and serve to outline and complement the studies also disseminated in the papers: a validation study of a statistical instrument designed to measure students self-direction, the Oddi Continuing Learning Inventory (OCLI), the application of the OCLI on three cohorts of students from two different educational programs at AAU and, lastly, a explorative interview study of students' self-directed practices in the problem- and project-based participant-directed teamwork of AAU.

Paper 1 presents an analysis of the performance of the OCLI when applied on AAU PBL students to answer the first research question of the thesis: "To what extent can a measure such as the Oddi Continuing Learning Inventory (OCLI) give insights into SDL in problem- and project-based learning?" The study utilizes an exploratory application of confirmatory factor analysis and scale purification, adhering to established and often-applied thresholds for fit indices. Moreover, the convergent validity of the scale is assessed through the inclusion of two other instruments, and the new factor structure resulting from the analysis is interpreted. The study concludes that the OCLI, keeping the identified limitations in mind, can be applied to measure the SDL of AAU PBL students and that the methodology applied could be used to revalidate and assess other statistical instruments.

Paper 2 disseminates the findings from an application of the OCLI to students from two different study programs at AAU. The students were recruited from three different generations to allow for comparison between students during their first, second, and third year of study to answer the second research question: "Do AAU PBL students become more self-directed in their approach to learning?" The findings indicate that the students become more self-directed as they progress in their studies at AAU, but also that the progression is not linear, but rather encompasses two separate statistically significant developments: a rise in their ability to be self-regulated from the first to the second year, and a rise in their internal locus of control from the second to the third.

Paper 3 applies a thematic analysis to semi-structured and open-ended interviews with students from the same population as studied in paper 2, to attempt to answer the third research question, "How do students practice SDL in problem- and project-based teamwork at AAU?" The interview methodology was exploratory in nature, only minimally introducing the structure of the interview protocol to mitigate the potential for inadvertent influence on the informants, using the interview protocol as a thematic checklist. The study adopts an innovative approach in reporting its findings by presenting a select number of extended, contextually rich narratives. The findings show that the informants shape the practices of the participant-directed teamwork primarily through two different forms of negotiations. Initially, at the onset of new team projects, all students partake in aligning expectations, although the methods of this alignment vary substantially. Additionally, the findings indicate that beyond initial discussions, students engage in the renegotiation of practices during episodes of conflict intervention.

In summary, the thesis contributes to the understanding of the connection between SDL and the problem- and project-based learning implemented at AAU in

several different ways. The findings generally support the notion that students engaged in PBL become more self-directed in their approach to learning, and that the issues often faced by learners transitioning to learning environments that require them to be self-directed are mitigated appropriately at AAU. The findings also advance the understanding of the relationship between SDL and teamwork by examining student experiences of negotiating common practices in project-based teamwork.

DANSK RESUME

Mange nutidige visioner for fremtidens uddannelse understreger nødvendigheden af pædagogiske tilgange, der fremmer tilpasningsevnen til skiftende kompetencekrav, og påpeger i den sammenhæng behovet for udviklingen af evnen til selvstyret læring (SDL). Problem Baseret Læring (PBL) fremhæves ofte som et effektivt middel til at forbedre SDL. Forskning tyder på, at PBL forbedrer studerendes autonome læring, metakognitiv regulering, kritisk tænkning, selvstændighed, parathed til SDL og generelle evner til research. Centralt for alle PBL-modeller er de studerendes medbestemmelse og aktive rolle i læringsprocessen, et princip, der konsekvent anvendes i forskellige PBL-implementeringer blandt andet for at fremme intrinsisk motivation. Effektiviteten af PBL 's evne til at fremme SDL er dog ikke ensidigt bekræftet da nogle studier har skabt tvivl om korrelationens styrke.

En mulig kilde til de uoverensstemmelser der eksisterer i forskningsresultaterne, kan stamme fra den store varians i hvordan PBL er implementeret og SDL er blevet konceptualiseret og undersøgt på. De forskellige implementeringer af PBL og integrationen på tværs af discipliner, først i medicinsk uddannelse og senere i felter som ingeniørvidenskab, har ført til en række varierede modeller og praksisser. Denne store varians har skabt behov for en mere grundig granskning af effekten af den forskellige modeller og en højere gennemsigtighed af forskning indenfor PBL. Tidligere forskning, der har indikeret forbindelser mellem PBL og SDL, har primært været udført inden for case-baserede tilgange i medicinsk uddannelse. Denne afhandling forsker imidlertid i SDL i et bredere udvalg af discipliner inden for Aalborg Universitets problem- og projektbaserede model af PBL, som er systematisk implementeret på alle uddannelser.

Denne ph.d.-afhandling har til formål at undersøge udviklingen og praktiseringen af SDL blandt studerende i det problem- og projektbaserede læringsmiljø på Aalborg Universitet. Forskningen formidles primært gennem 3 artikler, og undersøgelsen blev gennemført i 4 faser. I andet kapitel, der redegør for første fase af afhandlingens forskning, gives der et historisk overblik der har til formål at beramme de efterfølgende undersøgelser. I kapitlet gennemgås historiske antagelser om læring, de først skelsættende undersøgelser der var med til at cementere og afgrænse SDL som begreb, de senere dominerende forståelser og debatter om SDL og afslutningsvist forholdet imellem SDL og PBL.

De tre efterfølgende faser redegøres der for i hvert deres kapitel i afhandlingen der tjener til at opridse og supplere de undersøgelser, der også formidles i artiklerne: en valideringsundersøgelse af et statistisk instrument designet til at måle studerendes selvstyring, Oddi Continuing Learning Inventory (OCLI), anvendelsen af OCLI på tre årgange af studerende fra to forskellige uddannelser på AAU, og endelig en eksplorativ interviewundersøgelse af studerendes selvstyrende praksisser i det problem- og projektbaserede, deltagerstyrede teamarbejde på AAU.

Artikel 1 præsenterer en analyse af OCLI's validitet, når den anvendes på AAU PBL-studerende og søger at besvare det første forskningsspørgsmål i afhandlingen: "I hvilket omfang kan et instrument som Oddi Continuing Learning Inventory (OCLI) give indsigt i SDL i problem- og projektbaseret læring?". Undersøgelsen benytter en eksplorativ anvendelse af konfirmativ faktoranalyse og ”scale purification”, og anvender etablerede og ofte anvendte tærskler for fit-indekser til at vurdere instrumentet. Desuden vurderes skalaens konvergente validitet ved at inddrage to andre instrumenter, og den nye faktorstruktur, der er resultatet af analysen, fortolkes. Undersøgelsen konkluderer, at OCLI, med de identificerede begrænsninger in mente, kan anvendes til at måle SDL hos PBL-studerende på AAU, og at den anvendte metode kan bruges til at validere og vurdere andre lignende statistiske instrumenter.

Artikel 2 redegør for resultaterne af en anvendelse af OCLI på studerende fra to forskellige uddannelser på AAU. Respondenter blev rekrutteret fra tre forskellige generationer for at muliggøre sammenligning mellem studerende i løbet af deres hhv. første, andet og tredje studieår for at kunne besvare det andet forskningsspørgsmål: "Bliver AAU's PBL-studerende mere selvstyrende i deres tilgang til læring?". Resultaterne viser, at de studerende bliver mere selvstyrende, jo længere i deres studier på AAU de kommer, men også at udviklingen ikke er lineær. Stigningen i OCLI-scoren omfatter to separate statistisk signifikante udviklinger: en stigning i deres evne til at være selvregulerende fra det første til det andet år, og en stigning i deres ”internal locus of control” fra det andet til det tredje.

Artikel 3 anvender en tematisk analytisk tilgang til semistrukturerede interviews med studerende fra den samme population som undersøgt i artikel 2, for at forsøge at besvare det tredje forskningsspørgsmål: "Hvordan praktiserer studerende SDL i det problem- og projektbaseret teamwork på AAU?". Der er anvendt en eksplorativ interviewtilgang således at interviewprotokollen anvendes minimalt for at mindske risikoen for utilsigtet påvirkning af informanterne. Undersøgelsen rapporterer resultaterne igennem et udvalgt antal udvidede, kontekstuelt rige fortællinger. Resultaterne viser, at informanterne former deres fælles praksisser i det

deltagerstyrede teamarbejde primært gennem to forskellige former for forhandlinger. Samtlige studerende rapporterer at de i begyndelsen af nye projekter foretager en eller anden form for forventningsafstemning, men formatet varierer meget. Desuden indikerer undersøgelsen at de studerende igennem håndtering af konflikter indgår i genforhandlinger af fælles praksisser.

Afhandlingen bidrager samlet set til forståelsen af sammenhængen mellem SDL og den problem- og projektbaserede læring, der er implementeret på AAU, på flere forskellige måder. Resultaterne understøtter generelt forestillingen om, at studerende, der er engageret i PBL, bliver mere selvstyrende i deres tilgang til læring, og at de problemer, som studerende ofte står over for, når de skifter til læringsmiljøer, der kræver, at de er selvstyrende, bliver afbødet på passende vis på AAU. Undersøgelserne fremmer også forståelsen af forholdet mellem SDL og teamwork ved at undersøge de studerendes erfaringer med at forhandle fælles praksis i projektbaseret teamwork.

LIST OF ARTICLES

The thesis is based on three articles:

1. Clausen, N. R., & Hansen, C. D. (2022). Revitalizing the Oddi Continuing Learning Inventory. International Journal of Learning, Teaching and Educational Research, 21(5), Article 5. https://ijlter.org/index.php/ijlter/article/view/5026

2. Clausen, N. R. (2021). Progression of Self-Directed Learning in PBL: Comparing Consecutive Semesters at AAU. Journal of Problem Based Learning in Higher Education, 9(1), Article 1. https://doi.org/10.5278/ojs.jpblhe.v9i1.6373

3. Clausen, N. R. (2023). A little bit of trouble: Negotiating collaborative practices in student-centered teamwork. Manuscript submitted for publication.

Other related publications:

[1] Clausen, N. R., & Kolmos, A. (2019). PBL Future work report 1: Preliminary findings of the staff survey: Presentation of frequencies on faculty level from the staff survey. In PBL Future work report 1: Preliminary findings of the staff survey [Report]. Aalborg University.

[2] Clausen, N. R., & Kolmos, A. (2019). PBL Future work report 2: Preliminary findings of the student survey. Presentation of frequencies on faculty level. In PBL Future work report 2 [Report]. Aalborg University.

[3] 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. https://vbn.aau.dk/en/publications/a-comparative-curriculum-analysis-of-two-pbl-engineering-programs

[4] Boelt, A. M., Kristensen, N. S., & Clausen, N. R. (2020). Classification and framing in PBL: A Case Study. Educate for the Future: PBL, Sustainability and Digitalisation 2020, 343–353.

[5] Kolmos, A., Holgaard, J. E., & Clausen, N. R. (2020). Progression of student self-assessed learning outcomes in systemic PBL. European Journal of Engineering Education, 1–23. Scopus. https://doi.org/10.1080/03043797.2020.1789070

[6] 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.

[7] Clausen, N. R., Ulseth, R., & Johnson, B. (2021). Analysing self-directed learning at iron range engineering: 8th International Research Symposium on Problem-Based Learning, IRSPBL 2021. Transforming PBL Through Hybrid Learning Models, 3–12.

[8] Chen, J., Kolmos, A., & Clausen, N. R. (2023). Gender Differences in Engineering Students' Understanding of Professional Competences and Career Development in the Transition from Education to Work. International Journal of Technology and Design Education, 33(3), 1121–1142. https://doi.org/10.1007/s10798-022-09759-w

[9] Boelt, A. M., & Clausen, N. R. (2023). Participant Direction. in A. Kolmos & T. Ryberg (Eds.), PBL in a Digital Age (pp. 39–52). Aalborg Universitetsforlag.

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1. Introduction

Many contemporary visions for education have highlighted the need for an increased focus on competence for self-directed, continuous, and lifelong learning (OECD, 2019, 2022; UNESCO, 2017). These frameworks point towards a need for heightened flexibility and the ability to adjust to new needs for competences more often throughout life. One proposed solution centers on fostering students' learning abilities, particularly their capacity for autonomous learning independent of teacher guidance. Self-directed learning (SDL) has been introduced as a potential mechanism to address this emerging need.

Among learning methodologies, problem-based learning (PBL) is frequently cited for its potential to foster SDL (Blumberg, 2000; Ge & Chua, 2019; Kivela & Kivela, 2005; Leary et al., 2019; Loyens et al., 2008). Although SDL is often highlighted both as a prerequisite for, *and* an advantageous learning outcome of, PBL, there is conflicting evidence as to whether this is actually the case (Hung, 2011). Several studies substantiate the idea that students engaged in PBL exhibit an increased propensity for self-directed learning. Empirical evidence highlights various facets of this development, including an elevation in self-directed learning skills (Leary, 2012), metacognitive self-regulation, and critical thinking (Sungur & Tekkaya, 2006), an increase in readiness for self-directed learning (Litzinger et al., 2005), enhanced library research competencies (Blumberg, 2000), more autonomous selection of academic literature (Blumberg & Michael, 1992), and the application of effective study strategies (Blumberg, 2000; Hmelo & Lin, 2000; Sungur & Tekkaya, 2006). Additionally, both students and educators have reported perceptions of heightened self-direction (Blumberg, 2000; Lutsenko, 2018). Furthermore, multiple studies suggest that students become increasingly self-reliant as they progress through their PBL courses (Blumberg & Michael, 1992; Hmelo-Silver, 2004).

Contrastingly, some investigations identified discordant findings, challenging the presumed link between PBL and self-directed learning. Notably, Harvey et al. (2003) failed to observe a significant increase in self-direction among PBL students, while Schmidt (2000) critically examined the foundational assumptions connecting self-directed learning and PBL, questioning whether self-direction attained in an educational PBL setting transfers to professional practice. Given the variation in how PBL is applied, and how SDL is conceptualized and measured, it is not surprising that these discrepancies exist and recent studies have called for studies to heighten our understanding of SDL in PBL (Chen et al., 2021; Hmelo-Silver, 2009; Servant-Miklos et al., 2019).

PBL has garnered significant popularity chiefly through its implementation in medical and engineering educational curricula. Initially, the adoption of case-based PBL methods within medical education set the foundational parameters for PBL as an educational approach, but in subsequent years, more project-oriented methodologies have gained traction, not only in engineering education but also in other disciplines (Chen et al., 2021; Leary, 2012; Servant-Miklos et al., 2019; Walker & Leary, 2009). In the scientific literature it is too often commonplace to conflate between the approaches and implementations although they vary considerably (Hmelo-Silver, 2004; Hung, 2011). As highlighted by past research, efforts have been made to create models or frameworks that can encompass the plethora of approaches to PBL (Barrows, 1986; Savery, 2015; Savin-Baden, 2014), and although they have often instigated discussions on PBL that have encompassed its foundational theoretical assumptions and/or associated student learning outcomes, the discrepancies in the actual implementation of PBL frequently remain under-examined (Hung, 2011). Even when restricting the focus to applications within engineering education, recent reviews have revealed a plethora of diverse models and degrees of implementation, and attempts to establish typologies for PBL practice has similarly indicated considerable variability (Chen et al., 2021). However, both the case and project-based models emphasize that students should be given added responsibility for their own learning process, thereby achieving elevated levels of intrinsic motivation, making self-direction an integral part and fundamental principle of PBL (de Graaff & Kolmos, 2003; Ge & Chua, 2019; Servant-Miklos et al., 2019). Consequently, SDL has played a central role in PBL throughout its history, and has been reported as both a highly advantageous learning outcome *of*, and a necessity *for,* students to succeed in the model (Blumberg, 2000; de Graaff & Kolmos, 2003; Dolmans et al., 2016).

One of the institutions known for applying the problem- and project-based learning approach is Aalborg University (AAU), which has implemented systemic PBL across all faculties and institutes (A. Kolmos et al., 2004; A. Kolmos & Ryberg, 2023). At AAU, students collaborate in groups, submit a joint project report, and participate in a collective examination, while individual grades are awarded (A. Kolmos et al., 2004). The students work on projects in more than 90% of all semesters, and over 60% of students report dedicating more than half of their university time to these projects (Clausen & Kolmos, 2019). Although variations exist, a typical semester at AAU comprises 15 ECTS (European Credit Transfer System) for traditional, often lecture-based, domain-specific courses and an equivalent 15 ECTS allocated to problem-based participant-directed project teamwork (de Graaff & Kolmos, 2007;

A. Kolmos et al., 2004). The 15 ECTS for problem-based projects typically encompass a single semester-long project, using a problem as the catalyst for the learning process. The learning process in the semester-project is social, team-based, and participant-directed:

> The social approach is team-based learning. The team learning aspect underpins the learning process as a social act where learning takes place through dialogue and communication. But the students are not only learning from each other – they also learn to share knowledge and organize the process of collaborative learning. The social approach also covers the concept of **participant-directed learning**, which indicates who has the ownership of the learning process and, especially, the formulation of the problem.*(de Graaff & Kolmos, 2007, p. 7)*

Thus, in the problem- and project-based model of AAU PBL, it is through the participant-directed social learning process, which is organized in problem-based project teamwork, that the student's self-directedness is practiced. The individual student's preferences and self-directed inclinations are, through social practices such as negotiation and organization, transformed into collective practices within the participant-directed team framework. The aim of this study is to study these practices, the students' individual developments of self-direction, and the purported connection between AAU PBL and SDL.

1.1 Research questions

The primary objective of the PhD was to study the development of SDL in students in a PBL environment at AAU. Investigating to what extent the students at AAU become self-directed learners was a main focus, and even though earlier studies have shown some connections between PBL and SDL, they have mostly looked into the field of case-based PBL in medical education, whereas I focus on other students in AAUs model of problem- and project-based learning across multiple disciplines (Bosch & Goede, 2019; de Graaff & Kolmos, 2007; Guerra & Kolmos, 2011; Hmelo-Silver, 2004). The overarching purpose of the thesis can be defined as contributing to answering:

What can be learned from using self-directed learning to research problem- and project-based learning?

To address the overarching purpose and lay the foundation for the ensuing empirical investigations, this study commenced by scrutinizing the conceptualizations and interpretations of SDL as employed in prior research endeavors. A historical examination of the literature illuminated the underlying assumptions of SDL, its antecedent conceptualizations, and its integration into research and theories related to PBL. This examination is detailed in Chapter 2.

While the overarching purpose guided this thesis and is addressed in the concluding chapters, to facilitate an exploration of aspects that contribute to answering it, three subordinate research questions were operationalized:

1. **To what extent can a measure such as the Oddi Continuing Learning Inventory (OCLI) give insights into SDL in problem- and project-based learning?**

As has been substantiated in the introduction, there is conflicting evidence as to whether PBL fosters SDL in students. To address this issue, efforts have been made to identify a method of measuring students' SDL. As a part of this effort, the OCLI, a statistical instrument for measuring student inclination towards SDL as expressed through behaviors and attitudes, has been identified as a candidate. However, the OCLI cannot be applied without first revalidating it according to present day statistical methods in a setting appropriately similar to AAU. Answering this research question accounts for the results of the efforts to revalidate the OCLI.

2. **Do AAU PBL students become more self-directed in their approach to learning?**

After validation, the identified statistical instrument was applied on AAU PBL students and their responses analyzed to attempt to answer whether they become more inclined towards self-direction in learning.

3. **How do students practice SDL in problem- and project-based teamwork at AAU?**

One of the distinguishing features of AAU PBL, which will be elaborated on in the subsequent subchapter about the research context, is its adherence to participant-directed problem- and project-based teamwork. Within the context of said collaborative teamwork, students cultivate collective practices of participant- and/or self-directed learning, which constitute the primary focus of the study. The

research question will be addressed by investigating the manner in which AAU students engage in PBL practice SDL. This investigation will be undertaken utilizing an inductive thematic analysis of data garnered from individual interviews with students.

1.2 Research design

This thesis aims to explore students' self-direction as learners in a problem-based project-oriented learning environment like AAU. Through an initial exploration of the research literature on SDL in PBL it became clear that while there are strong theoretical ties between the two concepts, the empirical evidence for the purported connection is both limited and contradictory. This led me to design a study which can largely be subdivided into four different supplementary parts, which all contribute to a more complete and holistic understanding of SDL in AAU PBL students.

First Phase	investigate how SDL has been conceptualized and understood, both within scientific literature as a whole and PBL literature specifically through an exploration of the research and literature on SDL and SDL in PBL. This overview begins by delving into the historical context in which SDL was originally conceptualized, as well as some of the contemporary prevailing assumptions about learning. Subsequently, seminal studies that were instrumental in identifying the existence, characteristics, and extent of self-direction in learners are presented. Finally, the evolving discussions and conceptualizations that have been influential in shaping the research landscape to date and the connection between SDL and PBL are explored. This phase is disseminated in chapter 2.
Second Phase	Analyze whether the application of a measure such as the OCLI can give insights into SDL in PBL by revalidating the OCLI, applying present day standards for instrument validation. In the second phase of the study, it was the goal to find a way of measuring an individual student's propensity towards self-direction in learning. To this end, a suitable statistical instrument (OCLI) was identified, but before

	application it was deemed appropriate for it to be revalidated in a context similar to the one in which it was intended to be applied. An exploratory application of confirmatory factor analysis and scale purification was conducted, and a new factor structure identified. The study supports the continued use of the OCLI with certain limitations in mind. This phase is disseminated in chapter 3 and paper 1 (Clausen & Hansen, 2022).
Third Phase	Attempt to measure whether AAU PBL students become increasingly more self-directed as they progress their studies through an application of the OCLI on AAU students. During the third phase, the OCLI was applied on a population of students from three different generations in the same study programs to ascertain whether they became increasingly self-directed during their enrollment at AAU and in what way. This phase is disseminated in chapter 4 and paper 2 (Clausen, 2021).
Fourth Phase	Explore how the students manage shared self-directed practices during problem-based project-oriented teamwork. In the fourth phase of the study, interviews with students were conducted to explore how self-directed learning is expressed and managed during problem-based project-oriented teamwork at AAU. An inductive thematic analysis of the interviews was conducted and identified several ways that students negotiate shared self-directed practices during problem-based project-oriented teamwork. This phase in disseminated in chapter 5 and paper 3 (Clausen, 2023).

The research design applied in the third and fourth phase, to explore SDL in a AAU PBL setting, was chosen in part to improve the convergent validity of the results and attempt to avoid monomethod bias and unwarranted generalizations (Campbell & Fiske, 1959; Frederiksen, 2020; Webb et al., 1966). Another key

consideration in designing the study was how to encompass some way of measuring a student's level of SDL without becoming overly deductive, reducing the complexity of SDL, and risking conceptual determinism, like previous SDL research has been accused of (Brockett, 1985a; Brookfield, 1981, 1985; Tough, 1971). Exploring the complexity and interplay between SDL and AAU PBL in an exploratory fashion, while also assessing the student's individual level of SDL, was deemed to require two separate data collections and analysis. A research design where a broad, often quantitative, analysis is followed by a more exploratory, often qualitative, analysis is especially advantageous when working with problems where a broad general understanding is initially needed, but will not suffice (Creswell, 2013). Applying multiple data collections and analysis is often a favorable alternative when it is deemed that neither quantitative nor qualitative methods alone can adequately capture the desired complexity, details and/or width of a given phenomenon, allowing researchers to let the methods complement each other, seeing different aspects and angles (Bryman, 2008; Creswell & Creswell, 2018).

In this study it was vital to ascertain whether the students actually become more self-directed before attempting to explore how they practice SDL during their studies in the problem- and project-based AAU PBL model. In this thesis, the qualitative research of phase four was thus informed by the results from the quantitative but was conducted as an exploratory and inductive study where the collected data, not the results of the preceding quantitative analysis, dictated the analytical focus.

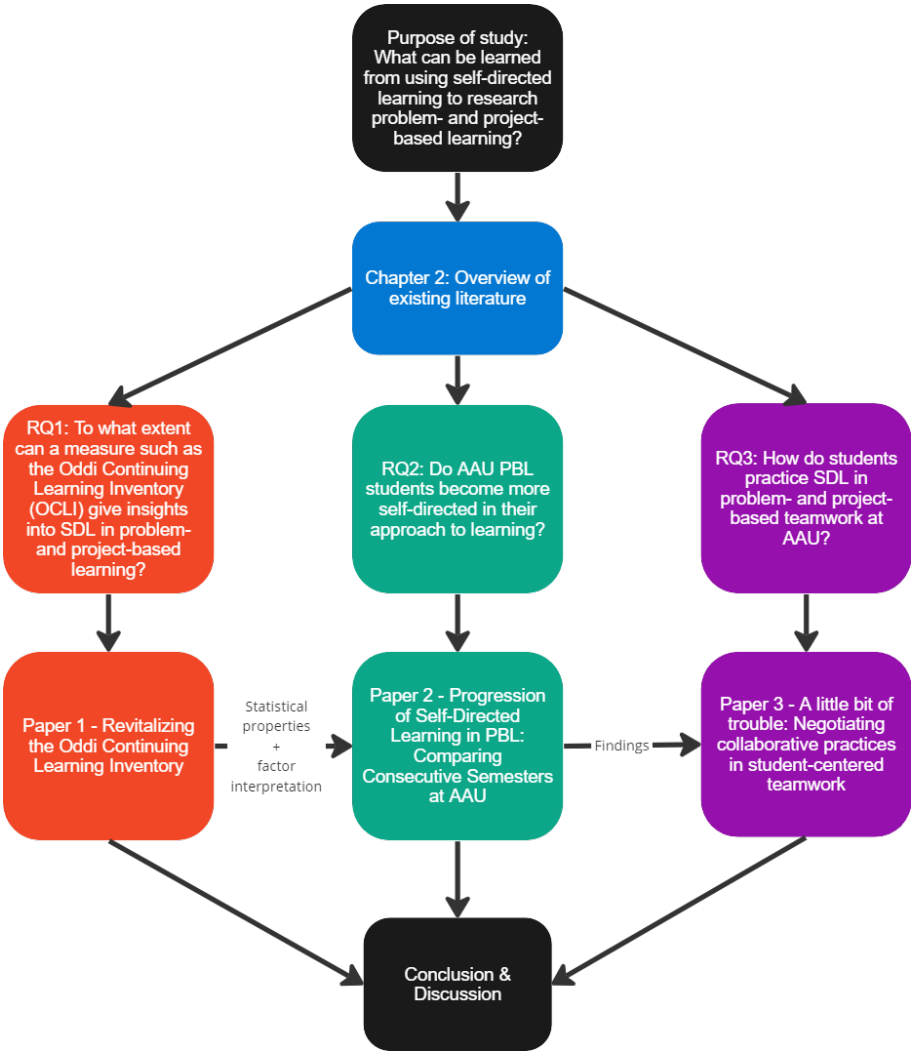

Figure 1. Outline of phases and their connections. Phase one: Blue, Phase two: Orange, Phase three: Teal, Phase four: Purple.

1.3 Context of the empirical studies

AAU is one of a few reform universities started in the 1960s and 70s which challenged traditional ways of organizing teaching in higher education, by suggesting alternatives to the mass lectures attended by hundreds of students at a time. AAU adopted a problem-based approach, organized in extended participant-directed projects run by the students alongside more traditional, typically lecture-based domain-specific courses (de Graaff & Kolmos, 2007). AAU applies a systemic PBL model that is a combination of problem-based and project-organized learning, students typically working on semester-long projects every semester and using a problem as instigation for the learning process.

A challenge for the study was how to handle the variation in how PBL is applied in different study programs across AAU, without including groups of students undergoing vastly different study experiences in one large pool of respondents, only united by the overarching institutional model of PBL. To mitigate this problem, multiple cases were selected, each case made up of students from a particular study program, to ensure an appropriate level of internal consistency in the cases in terms of curriculum, physical study environment etc. In the two empirical studies outlined in chapters 4 and 5 and papers 2 and 3, I studied students from sociology and data science. These students were chosen because they represent vastly different professional traditions, thus ensuring that our findings are not only the results of a specific implementation of the model in that particular field, and because both study programs have large cohorts of students, making it feasible to find enough respondents for the study.

The validation study accounted for in chapter 3 and paper 1 recruited respondents from two different study programs who are only a part of the initial study. The respondents from this study are only a part of this validation study and not a part of the cohorts studied in the two following. The two subsequent studies reported in papers 2 and 3 and chapters 4 and 5 recruited other students as respondents, but share the same population between them, a design feature chosen to ensure the comparability of the results. For additional information about the respondents, informants, and context of each study, the reader is directed to the corresponding paper

.

1.4 Outline of the thesis

Chapter 2 delves into the understandings of SDL through a historical literature overview of pertinent scientific literature. The chapter begins by contextualizing the historical backdrop and the prevailing perspectives on adult learning from which SDL emerged. Subsequent segments of the chapter examine research endeavors aimed at establishing the existence of self-direction in learners, its prevalence, the dominant assumptions and understandings concerning self-directed learners, and the methodologies employed to gauge an individual's propensity for, or capacity to, engage in SDL. The chapter concludes by examining the role of SDL within the framework of PBL, with a special emphasis on its application at AAU.

The subsequent three chapters are dedicated to addressing each of the subordinate research questions. Each chapter commences with a summary of the research undertaken to attempt to answer the research question, followed by supplementary information and commentary on both the summary and the associated paper. This format was chosen to facilitate a seamless reading experience of the thesis, minimizing the need for readers to frequently refer to the original papers. Consequently, some information from the papers may be reiterated in the summary and findings sections of each chapter.

Chapter 3 outlines the process of revalidating the Oddi Continuing Learning Inventory (OCLI), an instrument designed to assess an individual's inclination towards self-direction in learning. This effort takes aim at answering the first subordinate research question and the results are also reported in paper 1 (Clausen & Hansen, 2022). The chapter further elaborates on the review of prior validation studies pertaining to the OCLI present in the paper. It presents the findings and engages in a critical discussion regarding further limitations inherent to the validation study.

Chapter 4 addresses the second research question, where findings from the application of the newly validated OCLI are presented. The OCLI was distributed to three cohorts of bachelor's students in the data science and sociology programs at AAU. The results are reported in paper 2 (Clausen, 2021), and Chapter 4 expands on the methodological framework and discussion to elucidate the findings.

Chapter 5 presents the results of the efforts to address the third research question through an inductive thematic analysis based on exploratory interviews, as detailed in paper 3 (Clausen, 2023). This chapter specifically examines students' SDL as

manifested within the framework of problem- and project-based participant-directed teamwork at AAU. Additionally, the chapter elaborates on methodological considerations, and offers an extended discussion of the results.

Chapter 6 consolidates the findings, offering a conclusion and discussion in relation to the overarching research purpose. This is complemented by recommendations for practical implications and suggestions for future research directions.

2. Framing the research: SDL & SDL in PBL

In this chapter, a comprehensive historical overview of pertinent literature aims to inform and frame the following studies in the existing literature and research of the field. Initially, the historical and contemporary underlying assumptions about learning, and especially adult learners, are presented. The development in historical psychological assumptions were essential to the rise of adult education as a research field and consequently to the conceptualization of SDL. Accordingly, this chapter commences with a succinct overview of historical psychological theories underpinning SDL and adult learning to inform the rest of the chapter.

2.1 Can adults actually learn?

To understand the origin of SDL, it is essential to acknowledge the broader field from which it emerged, namely adult learning and education, and its foundational preconditions. In contemporary times, the idea that adults engage in learning, both within formal educational settings and beyond, appears unassailably evident. This is exemplified, for instance, by the substantial enrollment of adult students in universities globally. However, when delving into the historical backdrop, it becomes almost paradoxically amusing to note that as recently as the late 19th century, the very notion of adult learning capabilities was a matter of contentious debate. Renowned philosopher and psychologist William James wrote of the possibility of adults learning that:

> Outside of their own business, the ideas gained by men before they are twenty-five are practically the only ideas they shall have in their lives. They cannot get anything new. Disinterested curiosity is past, the mental grooves and channels set, the power of assimilation gone. *(James, 1890, p. 304)*

While James did not categorically dismiss the idea that adults are capable of modifying their cognitive functions, he expressed considerable skepticism concerning the potential for adults to assimilate profoundly novel ideas or undergo significant paradigmatic shifts. In the subsequent century, the field of learning psychology underwent significant transformations, and by the late 1910s, the distinctions between the young and adult brain were often understood through the concept of neural plasticity. According to this theory, the plasticity of the young brain was considered the paramount characteristic that facilitated the type of learning perceived to be exclusive to children, but also that adults might possess

other attributes that could support learning in different ways. Freeman, a prominent educational psychologist of the era, explained the differences between child and adult learning through a metaphor of language, elaborating on the views of elasticity and differences of approaches to learning new material:

> It may very well be that the adult can attain more rapid improvement because he has more older habits which can be applied in a new problem, but that he cannot finally attain such a high rank, because of the fact that the older habits are not exactly like the ones which have to be formed in the new task, and that therefore they interfere with the formation of the newer habits. This conclusion would seem to be supported by the fact that adults rarely learn to pronounce foreign languages without an accent. . . . The child's plasticity favors imitation as a method of learning. When the adult sees another person perform a new act he has a tendency to translate it in terms of acts which he himself can perform. He is limited, so to speak, by the vocabulary of action which he already possesses. *(Freeman, 1917)*

The characteristics of child and adult learning highlighted by Freeman above are central, even if rarely referenced directly, to many of the later conceptualizations related to adult learning, such as andragogy, self-teaching, self-directed and self-initiated learning (Knowles, 1980b; Oddi, 1987, p. 19; Penland, 1979; Tough, 1967). The understanding also spurred renowned educational psychologist Edward Thorndike, alongside other scholars, to conduct empirical investigations to challenge the prevailing notion that "you cannot teach an old dog new tricks" (Thorndike et al., 1928). Although this idea was controversial at the time, Thorndike and his colleagues discovered no compelling evidence to suggest that adults encountered greater difficulties in learning compared to children. They summarized that:

> In their experiences, interests, and motives adults obviously differ from adolescents, but in the nature of the learning process they are substantially alike, so far as we can see. (…) If they [our studies] are verified, we may conclude that the general laws of learning are substantially the same from fifteen to fifty. *(Thorndike et al., 1928, p. 168)*

The findings of Thorndike et al., which indicated significant disparities in interests and motives between adult and child learners, and that these differences are the main points of variation, have also been a recurring theme within the field of adult and self-directed learning. These differences are frequent themes and central in the works of, among others, prominent scholars such as Cyril Houle and Malcolm Knowles and their characterization of self-directed learners (Houle, 1961; Knowles, 1970, 1975, 1980b). While Thorndike and his collaborators laid the foundational groundwork for recognizing adult learning capabilities, a comprehensive empirical investigation into adult learning mechanisms did not garner widespread scholarly attention until the decades of the 1960s and 1970s. It was within this historical framework that Cyril Houle, in collaboration with his subsequent protégés Allen Tough and Malcolm Knowles, disseminated seminal publications elucidating the unique characteristics of adult learning which we will return to later in this chapter. Their contributions marked a significant turning point in the field, sparking greater attention and research into understanding adult learning processes. Notably, between the eras of Thorndike and Houle, other seminal developments in educational psychology also emerged, serving as foundational elements for SDL. Carl Rogers, a renowned humanistic psychologist, wrote about his understanding of the process of learning that:

> I have come to feel that the only learning which significantly influences behavior is self-discovered, self-appropriated learning. *Such* self-discovered learning, truth that has been personally appropriated and assimilated in experience, cannot be directly communicated to another. *(Rogers, 1958, p. 4)*

Although Carl Rogers undoubtedly left a lasting impact on the field of education psychology through his advocacy for student-centered learning, it may be posited that his most salient contribution to the discourse on SDL resides in the impact his work had on key figures in the field, including Cyril Houle, Allen Tough and Malcolm Knowles (Brockett & Donaghy, 2005; Knowles et al., 2005; Servant-Miklos & Noordegraaf-Eelens, 2021).

From this we can see that the historical assumptions about the preconditions for adult learning changed rapidly from the 1890s onward. The early notion that mental grooves were fixed and that the plasticity present in children's and adolescents' brains was gone in adulthood was eventually supplanted. Empirical research demonstrated that, although the methods and approaches to learning may differ, adults do indeed possess the capacity for effective learning. That

foundational notion has significantly influenced subsequent research into adult education and SDL. The emergent assumptions regarding the distinct learning approaches and characteristics of children and adults are also manifestly reflected in the subsequent research endeavors and theoretical frameworks pertaining to adult learning and SDL.

2.2 Existence and extent of SDL

The inaugural empirical investigations into the concept of SDL commenced within the historical context outlined in the preceding section. These studies were some of the first to contribute empirically founded assumptions about self-directed learners and have greatly affected the conceptualizations of SDL that are prevalent in the present day. Pioneering scholars in the domain of adult education, including Cyril Houle (1961) and Allen Tough (1971), made landmark contributions in this area. Their exploratory empirical studies represented some of the earliest endeavors to elucidate the defining characteristics and theoretical underpinnings of SDL.

Cyril Houle sought to test the existence of self-directed learners and characterize the individuals whose surroundings could readily identify them as such. Houle's seminal work, *The Inquiring Mind,* released in 1961, describes the characteristic behaviours, motives, and activities of self-directed adult learners (Houle, 1961). Houle sought out individuals who were readily recognized as "self-directed continuing learners" within their respective communities and used an analysis of their approaches as the basis for his understanding. To accomplish this, he conducted a search in the vicinity of Chicago, actively seeking recommendations from people who could identify suitable candidates for his investigation. He personally interviewed all the identified "self-directed continuing learners" and discovered that many of them held firm convictions regarding the factors that had influenced their journey towards becoming self-directed learners. Some attributed their development to past teachers, personal qualities, or innate intelligence. Houle, however, drawing from his own extensive experience counselling adults seeking education, harbored reservations about the validity of their claims as the sole causes for their self-directed learning paths. Ultimately, Houle deduced that the most significant categorization of self-directed learners could be made based on their motivation for learning. He identified three main categories: *goal-oriented*, *activity-oriented*, and *learning-oriented*.

Goal-oriented learners were primarily driven by a specific learning objective, and their approach often resembled problem-orientation, as they sought to acquire

knowledge in a particular subject to overcome challenges in life, enhance their professional situation, or develop specific skills that would provide them with tangible benefits. Consequently, their continuing learning endeavors were often sporadic in nature and, in some cases, resembled obligatory or work-related activities, such as staying updated with the latest developments in a professional journal relevant to their occupation. Their learning efforts predominantly comprised individual and focused learning projects, driven by specific and well-defined personal desires or needs.

Activity-oriented learners were almost exclusively motivated by the social aspects of learning, often seeking refuge from loneliness, and actively pursuing the sense of community that learning environments provided. Houle encountered individuals who had regularly and consistently engaged in courses for upwards of 20-25 years, seemingly without any particular pattern or preference in their choice of topics. Among this group, various archetypes emerged. Some individuals participated in courses solely for the purpose of earning credits, showing little interest in the actual content. Others were driven by a sense of habit or tradition, while some sought the company of like-minded individuals, some hoping to find a potential life partner. Houle recounts stories of opening nights in evening schools, where participants from each course would gather in their respective classrooms. During such occasions, a significant portion of individuals would wander the halls, peeking into various classrooms before ultimately settling in the one with the most appealing group of people. Houle observed that activity-oriented learners were seldom highly engaged in the learning process. They typically neglected homework assignments and reading plans, unless these directly impacted their social interactions or were mandatory for credit. For these individuals, learning became a continuing activity as important, if not more so, to the social structure of their lives than was the learning itself.

Learning-oriented continuing learners, as the name implies, were motivated by the intrinsic value of learning and personal development. While one might assume similarities with goal-oriented learners, in reality, they differ significantly. Learning-oriented individuals often had distinct areas of interest and engaged in fields of study that they acknowledged they would never fully master, such as philosophy, natural sciences, or economics. In contrast, the goal-oriented learners typically had specific, finite, and well-defined problems they aimed to solve through their learning endeavors. Houle described his perspective on the distinction between learning-oriented and goal-oriented learners in the following manner:

> … a man reading a novel may be inferred to have a purpose in mind for reading it, but if he reads five novels a week, year after year, his habitual behavior as a novel-reader is more notable than the act of reading any individual novel. *(Houle, 1961, p. 24)*

According to Houle, such learners can scarcely be thought of as continuing learners, but rather as constant learners, as their motivation and interest in learning are consistently driven by intrinsic factors. It is important to note that these archetypes are rarely found in their pure form. In reality, most continuing learners exhibit traits that align with at least two of the aforementioned orientations, indicating a blending of motivations and interests in their learning pursuits. (Houle, 1961).

Another significant insight from his study is that there existed a discrepancy between the way most adult educators, policymakers, administrators, and even researchers perceived the motives and motivations of adult learners. They often assumed a simplistic causality between a specific interest or need and the individual's participation in an educational program or course, assuming that such participation would fulfil the identified need or interest. Houle, however, argued that this approach was overly simplistic. He highlighted that motives for participation and learning are much more multifaceted, influenced by a variety of factors such as values, habits, and interests. Furthermore, he emphasized that these motives are subject to constant change, indicating the dynamic nature of adult learners' motivations and laying the foundation for future theories of distinct approaches to learning (Houle, 1961, p. 80).

In his concluding remarks, Houle echoed the sentiment of Thorndike and eloquently encapsulated what would become one of his most significant contribution to research on adult and self-directed learning. He stated that:

> The university is distinguished from the kindergarten chiefly by the difference in the maturity of the student, and adult education is distinguished in the same way from the schooling provided to children and youth. The study of the individual has been accepted as an important starting-point at the earlier levels of education. The theory and practice of adult education will not progress very far until they are based on an understanding of how mature people approach the tasks and opportunities of adulthood. *(Houle, 1961, p. 81)*

Houle called for researchers, educators, and policymakers to recognize that children and adults possess distinct approaches to learning. He emphasized the need to gain a deeper understanding of the adult learner in order to enhance adult education as a whole. These pleas served as a catalyst for several investigations into processes, content, and motivations behind adult learning, most prominently, but not exclusively, undertaken by his own students, Allen Tough and Malcolm Knowles.

While Houle's most significant contribution was to underline the existence of self-directed continuous adult learners and their motivations for engaging in continuous learning efforts, Allen Tough sought to map out the extent of such efforts. Tough adopted a similarly empirical approach to studying adult learning, but his methodology was more rigid and deductive in nature than Houle's. His focus was primarily on exploring the extent and characteristics of actual learning projects undertaken by adult individuals. By focusing on specific learning projects, Tough sought to develop a methodology to outline quantifiable properties of each learning projects, allowing for comparison and widespread application. Allen Tough's approach involved studying specific learning projects undertaken by individuals. He defined learning projects as *"*a series of related episodes, adding up to at least seven hours. In each episode, more than half of the person's total motivation is to gain and retain certain fairly clear knowledge and skill, or to produce some other lasting change in himself*"* (Tough, 1971, p. 7). Tough argued that the seven-hour cut-off time, while arbitrary, made practical sense as it approximated a full day of full-time work. Additionally, during interviews, it allowed him to focus on what he deemed significant learning efforts and to avoid discussing smaller or unintentional activities.

In his seminal study, Tough, along with his research team, conducted 66 highly structured interviews. The findings revealed that the overwhelming majority of adults engage in major learning projects, averaging approximately eight such projects annually. Notably, 68 percent of these learning initiatives were self-planned by the learners, thereby contesting the prevailing presumption that the majority of such projects are institutionally initiated. Moreover, fewer than one percent of these projects were motivated by the objective of acquiring specific academic credits. These observations had far-reaching implications, underscoring the autonomy and self-directed characteristics inherent in adult learning activities (Tough, 1971).

Another notable and influential finding from Tough's initial study was that although learning projects were individually planned and thought out, the actual learning rarely occurred in isolation. Rather, it frequently entailed collaborative interactions and engagements with other individuals. This underscored the integral role of social dynamics and collaborative frameworks in adult learning, accentuating the importance of interpersonal relationships and networks in the enactment of self-directed learning processes (Tough, 1966, 1967). Tough derived a comprehensive model through observations and documented his findings, constructing linear models that encapsulated the customary approaches employed by his interview subjects. His work includes several important discoveries, with one particularly profound insight being the now thoroughly substantiated prevalence of self-initiated learning projects undertaken by most individuals on a regular basis.

The methodology developed by Allen Tough has had a significant and lasting impact on the field of SDL. His research design and method, centered around highly structured interview schemes, have been widely replicated and are considered among the most influential methods in the field. While Tough's methodology can hardly be said to have been explorative in nature, opting instead to adhere to rather strict interview schemes, focusing on replicability, his findings played a large part in outlining the subject of research (Brockett & Hiemstra, 1991).

Although Tough's study achieved significant success in terms of replicability and dissemination, it also faced substantial critical scrutiny. One notable reaction to the widespread use of Tough's methodology came from Brookfield (1981), who identified three key limitations that he believed were crucial to address. One of Brookfield's critiques pertained to the composition of Tough's initial sample, which predominantly consisted of highly educated individuals. Brookfield argued that this sample might be more inclined towards engaging in SDL compared to other segments of the general population. Subsequent studies made efforts to mitigate this concern, and while the findings have varied, it remains a contentious issue. Empirical evidence supports Brookfield's perspective to some extent, as studies featuring a larger number of individuals with lower or no formal education have generally demonstrated lower levels of self-planning (Brockett, 1983, 1985a; Brockett & Hiemstra, 1991). Tough himself acknowledged this limitation, underscoring the imperative of conducting additional research involving populations other than middle-class college graduates residing in urban areas (Brookfield, 1984; Tough, 1967). Several subsequent studies followed in the footsteps of Tough, adopting either the original interview guide or a modified

version thereof. These studies sought to build upon and address some of the acknowledged limitations of Tough's research. They specifically examined diverse contexts, such as rural areas and mothers with young children, among other populations (Coolican, 1973; Owen, 2002; Peters & Gordon, 1974). Brookfield additionally argued that the focus on noninstitutionalized learning was inappropriate within the economic climate of that era. It is important to recognize that Brookfield's viewpoint was rooted in a context that significantly differs from the present day (Brookfield, 1981).

Finally, Brookfield presented what he considered to be the methodological shortcomings of highly structured interviews. Brookfield pointed out that while the structure gave the advantage of replicability and comparability of the study and results, it also came with an inherent risk of constraining the interviewee's perspective to align with the interviewer's, potentially limiting the range of relevant and appropriate responses (Brookfield, 1981). This type of criticism is commonly raised when evaluating deductive research designs and is often considered a tradeoff inherent to the methodology. What makes this critique particularly pertinent in this case is the remarkable prevalence of Tough's methodology, which led to its dominant position within the field of research. Consequently, numerous conclusions about learning projects and self-directed learning were drawn based on this methodology, amplifying the potential consequences of any underlying limitations and conceptual determinism. One might argue that the learning project research field became a victim of its own success, with many prominent scholars considering its role to have been exhausted to the extent that further efforts employing the same methodology are redundant, if not harmful (Brookfield, 1981; Caffarella & O'Donnell, 1988).

Despite its limitations, learning project research has made significant contributions to SDL literature. Its primary objective was to investigate the number of projects individuals undertake and verify the existence and widespread nature of such endeavors, which it has accomplished with considerable success.

Following the cementing of the existence of SDL and the characterization of individuals readily identified as self-directed by Houle, and the prevalence of self-directed learning projects by Tough, several new avenues of research within the field began to gain momentum. Research into elements such as further validation of the existence and prevalence of self-directed learning (Penland, 1979; Tough, 1978), the assessment and evaluation of characteristics and attributes exhibited by self-directed learners (Ferrell, 1978; Guglielmino, 1977; Oddi, 1984, 1986), and

practical applications (Caffarella, 1985; Tough, 1982; Tough & Knowles, 1985) began to emerge. A particularly pertinent research direction for addressing the purpose of this chapter involves the development of theoretical frameworks that build upon and elaborate the empirically grounded insights gleaned from the studies conducted by Houle and Tough.

From this subchapter, it becomes apparent that research into SDL at this juncture encompassed a wide range of topics. While Houle focused on identifying characteristics of self-directed individuals, particularly their motivations, Tough examined comparable variables related to individuals' self-directed learning endeavors. Despite these efforts, the field encompassed no unified theoretical framework to define and understand SDL comprehensively.

2.3 Conceptualizations of SDL

2.3.1 Andragogy

One of the most renowned scholars to build upon the findings of Houle and Tough is Malcolm Knowles. Knowles gained recognition for popularizing the term "andragogy" in the research field of self-directed and adult learning. Initially, he defined it in contrast to "pedagogy," which refers to the art and science of teaching children. The term "andragogy" is constructed by replacing the Greek word for “child” (*paid*) with that for “man” (*anér/andr-*) and combining it with the word for “leading” (*agogus*) (Knowles et al., 2005). Initially, Knowles conceptualized andragogy as the art and science of teaching adults, perceiving it as being in direct opposition to the principles guiding the teaching of children. However, after engaging in correspondence with elementary and secondary school teachers who had effectively applied andragogy's principles, he revised his perspective. He began to view andragogy and pedagogy as parallel and distinct models, representing different assumptions about learners and existing at opposite ends of a spectrum (Knowles, 1970, 1980a). Knowles formulated his theory based on four non-exhaustive assumptions about the adult/andragogical learner, as summarized below.

1. Concept of the learner. Pedagogy assumes the learner to be highly dependent upon their teacher, relying on them to define what is important, when, and how it should be learned and subsequent validation that it has in fact been learned. In contrast, andragogy assumes that learners harbor a substantial psychological imperative for autonomy and self-direction, albeit with varying intensities. The

magnitude of this imperative is intrinsically linked to the second underlying assumption, concerning the learner's accumulation of prior experiences.

2. Role of learners' experience. As individuals progress in their growth and development, they amass a growing reservoir of experiences, which serves as a progressively valuable asset for both personal and collective learning. Knowles posited that this continuous accumulation alters the way individuals engage with experiences. For children, experiences are external events that happen *to* them, shaping their lives but remaining separate from their core identity. Children who are asked who they are will often rely on external factors such as their family, residence, and school to define themselves. In contrast, adults construct their self-identity on the foundation of their accrued experiences, defining themselves through an amalgamation of vocational pursuits, employment history, travel experiences, formal training, and achieved milestones. In essence, adults establish their identities by referencing their cumulative accomplishments. This intimate linkage between identity and experience cultivates a profound personal investment in the value of their experiences. Consequently, in situations where adults perceive their experiences as being marginalized or invalidated, the sentiment extends beyond mere dismissal of their experience; it is construed as an affront to their very sense of self (Knowles, 1980a).

Knowles therefore assumed that a traditional pedagogical learner's experience, like the child's, is of minimal importance to the ways in which the teacher approaches their learning, which will often take the form of direct transfer, through mediums like assigned reading or presentations. Conversely, andragogical learners, presumed to possess a greater wealth of experience, and to have made assumptions of their own based upon this experience, attaching personal meanings, opinions, and interpretations, will be less inclined to accept traditional pedagogical approaches because of those experiences and attachments. This perspective on the interplay between experiences, personal identity, and learning is clearly aligned with Rogers' theoretical framework of the organization of self and its implications in assimilating new experiences:

> Experience which, if assimilated, would involve a change in the organization of self tends to be resisted through denial or distortion of symbolization.
>
> The structure and organization of self appears to become more rigid under threats; to relax its boundaries when

> completely free from threat. Experience which is perceived as inconsistent with the self can only be assimilated if the current organization of self is relaxed and expanded to include it. *(Rogers, 1951, p. 390)*

Through constant expansion of one's frame of references and resulting rigidity of organization of self, the andragogical learner thus becomes less and less inclined towards traditional pedagogical/assimilative learning. This understanding by Rogers and Knowles also clearly echoes the metaphors of James and Freeman who conceptualized the rigidity of the organization of self or identity as the mental grooves being set and the plasticity of the brain being diminished (Freeman, 1917; James, 1890).

3. Readiness to learn. According to Knowles, pedagogical learners exhibit a readiness to acquire knowledge and skills that are deemed appropriate by society, particularly within the educational setting, when subjected to significant motivating factors such as the fear of failure. Readiness to learn is attributed to external pressures exerted by the learner's environment, including influences from parents, teachers, social interactions, and cultural factors. These external factors play a significant role in shaping and fostering the learner's readiness to engage in any given learning process.

Andragogy assumes that the learner becomes ready to learn something when they perceive a necessity to acquire knowledge or skills that will enable them to better manage real-life undertakings or challenges. This assumption, along with its subsequent implications, resonates prominently in contemporary educational frameworks related to "just-in-time" and problem-based learning.

4. Orientation to learning. The assumptions underlying pedagogy suggest that learners perceive education as a means of acquiring subject-specific knowledge. They acknowledge that even if they may not currently grasp the practical applications of the knowledge, they recognize its potential future relevance. Conversely, the andragogical assumption portrays learners as being more reliant on appreciating the immediate application of the knowledge they acquire. They seek learning experiences that have direct, tangible connections to their present circumstances and needs. This distinction in perspectives highlights the varying orientations towards the timing and purpose of learning between pedagogy and andragogy.

Malcolm Knowles perceived these assumptions as representing two ends of a spectrum, but he also described the maturation of learners as a four-point development encompassing that:

> 1) their self-concept moves from one of being a dependent personality toward being a self-directed human being; 2) they accumulate a growing reservoir of experience that becomes an increasingly rich resource for learning; 3) their readiness to learn becomes oriented increasingly to the developmental tasks of their social roles; and 4) their time perspective changes from one of postponed application of knowledge to immediacy of application, and accordingly, their orientation toward learning shifts from one of subject-centeredness to one of performance-centeredness. *(Knowles, 1980b, pp. 44–45)*

In Knowles' perspective, the reason why the traditional pedagogical approach does not fit the mature learners is, in short, because the learner has evolved from being a dependent and malleable "child" in need of orientation, to an experienced and self-directed adult with specific personal needs for knowledge and a continuously solidifying organization of self. Knowles later added that, as a practical implication, this means that the adult motivation for learning is distinguished by being more internal than external (Knowles, 1980a).

Despite having defined his understanding of self-direction in learners as a set of assumptions about their personal characteristics and preferences, one of the most widely applied definitions of SDL as a process was also formulated by Knowles. He states that SDL is a

> […] process in which individuals take the initiative, with or without the help from others, in diagnosing their learning needs, formulating goals, identifying human and material resources, choosing and implementing appropriate learning strategies, and evaluating learning outcomes. *(Knowles, 1975, p. 18)*

2.3.2 Critical theory and emancipatory knowledge

During the same period, other researchers inspired by critical theory, critical pedagogy, and transformative learning began to weigh in on how self-direction

should be understood. Mezirow and Brookfield argued that an important goal of SDL is to be transformational, that the learner becomes able to critically reflect on their own socioeconomic and cultural background and resulting assumptions (Brookfield, 1984, 1985; Mezirow, 1985a). Mezirow described the consequences of Jürgen Habermas' theory of communicative competence for adult education, stating that for learners to be truly self-directed they must reach a level of autonomy for which critical reflections about their own historical, cultural, and biographical contexts and backgrounds are a must (Habermas, 1971; Mezirow, 1985b). Mezirow reiterated Habermas´ theory of three learning domains in which humans generate knowledge, in a call for a more critical approach to adult learning. The distinction between the domains is based upon differences of interests which motivates the generation of said knowledge.

The first is the technical domain which refers to knowledge which allows humans to control and/or manipulate their environment. Technical knowledge is generated through the empirical-analytic sciences, applying techniques such as classical falsification and hypothetical-deductive theories. The goal of the technical domain is to generate and refine lawlike hypotheses which can be tested through experimentation and controlled observations so as to produce empirical generalizations with increasing validity.

The second is the practical domain which refers to knowledge that seeks to understand, describe, and explain through communicative action. Unlike technical knowledge, which relies on empirical verification and precise analytical statement, the practical domain studies social norms and derives its validity from intersubjective understandings and is upheld by broad acknowledgement of obligations. The goal of practical knowledge is clarification of the conditions for intersubjectivity and communication. Where the technical domain seeks to confirm its deductive assumptions through successful manipulation and control, the practical seeks subjective interpretative meaning through historical-hermeneutic sciences like descriptive social sciences, literary studies, history etc.

The third is the emancipatory domain which refers to knowledge gained through an interest in self-reflection. It involves studying how one's own biography, history, and cultural background has shaped the way one in situated and engages in social roles, institutions, and other structural frameworks. Emancipatory knowledge endeavors to critically examine aspects that are taken for granted as being beyond our control. Its purpose is to gain a deeper understanding of the subconscious rationales that underlie our actions and existence. Through illumination and

subsequent critique, emancipatory knowledge attempts to make humans critically conscious of how ideology effects and distorts their perceptions of reality (Habermas, 1971; Mezirow, 1981).

While the debate persists, it is evident that the majority of research efforts in the field, including the present study, fall primarily within the practical domain, attempting to understand and interpret intersubjective meaning through hermeneutic social sciences. Brookfield goes on to supply an alternative to Knowles' definition of SDL, stating what he believed should be the ideal for and definition of self-directed learning:

> This most fully adult form of self-directed learning is one in which critical reflection on the contingent aspects of reality, the exploration of alternative perspectives and meaning systems, and the alteration of personal and social circumstances, are all present. The external technical and the internal reflective dimensions are fused when adults come to appreciate the culturally constructed nature of knowledge and values and when they act on the basis of that appreciation to reinterpret and recreate their personal and social worlds. In such a praxis of thought and action is manifested a fully adult form of autonomous, self-directed learning. *(Brookfield, 1985)*

The definitions of SDL by Knowles and Brookfield encapsulate a fundamental and consistent contention in the field: whether SDL should be understood as a process, such as Knowles suggests, or as a change in consciousness as advocated by Brookfield. Brookfield, drawing on Boshier, proposed a distinction between the two approaches by utilizing the terminology of education and learning. According to Boshier, the internal psychological changes encompassing inclinations, behaviors, and attitudes should be considered as self-directed learning, while the process in which learners engage to plan their learning, set goals, locate suitable resources, etc., should be viewed as self-education (Brookfield, 1984). Brookfield further elaborated on the differences between the two conceptualizations, describing one as a process of developmental maturation resulting in internal changes in consciousness and the other as an assemblage of self-directional techniques that learners can acquire and implement, irrespective of their developmental stage (Brookfield, 1985).

2.3.3 Characteristics of self-directed learners

Parallel to and intertwined with the debates on the aims and definition of SDL, a growing focus within the field was devising methods to determine the degree of any given individual's self-directedness. While Tough had focused on the outcome of self-directed learning efforts and Houle on the motivations of people readily identified as self-directed continuous learners, other researchers began to theorize and research the characteristics of self-directed learners. Researchers started to derive specific attributes of self-directed learners that could be effectively evaluated through quantitative instruments. During the early stages of SDL research, Houle and Knowles explored the concept to some extent, generating theoretical assumptions about learners based mainly on their motivations. A subsequent wave of researchers became more focused on investigating ways of measuring learners' level of self-direction or readiness to engage in SDL.

During the 1960s and early 1970s, the first attempts to apply quantitative instruments to assess various aspects related to SDL emerged. One approach involved attempting to gauge the extent to which learners perceived themselves as possessing characteristics typically associated with self-actualization (Shostrom, 1964). Simultaneously, researchers directed their efforts towards quantifying learners' perceived control over their individual learning circumstances, utilizing established measures such as the Internal-External Scale developed by Rotter (1966). As the field evolved, a more specialized tool, the Autonomous Learner Index, emerged. This instrument was crafted to evaluate learners' attitudes and strategies towards independence in learning, encompassing a 20-item questionnaire (Ferrell, 1978).

However, these initial attempts to measure aspects related to SDL never gained much popularity in the field, which by the late 1970s had shifted its focus to trying to measure and compare SDL to other learning skills and predicting who could potentially be successful in a self-directed learning environment (Brockett & Hiemstra, 1991). To meet this end, Guglielmino developed the Self-Directed Learning Readiness Scale (SDLRS) to measure the attitudes, abilities, and characteristics that constituted an individual's readiness to engage in self-directed learning (Guglielmino, 1977). Despite the continued popularity of the SDLRS, which is one of the most widely applied instruments to measure SDL, debates emerged in the years following its conceptualization regarding its utility, and the appropriateness of its measurement and statistical properties (Boyer et al., 2014; Brockett, 1985b; Brookfield, 1985; Field, 1989; Long, 1987). A central point of

contention reiterates the debate already outlined about whether self-direction should be conceptualized as a role an individual can learn to adopt during a given learning process or as a set of personal characteristics attained through psychological development. Fellenz summarized the positions within SDL research thus:

> Two distinct approaches can be taken in any analysis of self-direction. The concept can be examined either as a role adopted during the process of learning or as a psychological state attained by an individual in personal development. Both factors can be viewed as developed abilities and, hence, analyzed both as to how they are learned and how they affect self-directed learning efforts. *(Fellenz, 1985, p. 164)*

2.3.4 Oddi Continuing Learning Inventory

One of the reactions to the debate and criticisms of the SDLRS was the development of the Oddi Continuing Learning Inventory (OCLI) (Oddi, 1984). Certain researchers contended that Guglielmino's conceptualization leaned excessively towards viewing SDL as an instructional method or a role that learners might adopt during their learning process, and argued instead for SDL to be understood as an outcome of psychological development (Brockett & Hiemstra, 1991; Brookfield, 1984; Oddi, 1987). Oddi developed the OCLI based on the latter understanding and argued that previous conceptualizations had focused too much on the use of specific methods and self-management, whereas her model focused on cognitive and emotive developments and resulting attitudes and behaviors (Oddi, 1984, 1986, 1987). Oddi also remarked, in agreement with Brockett, Brookfield and Griffin, that the research field was in dire need of a robust unified theoretical construct (Brockett, 1983; Brookfield, 1984; Griffin, 1983). Distinguishing her study from much of the previous work, she adopted the perspectives of educational scholars such a Bruner and Dewey, arguing that the process of instruction alone fell short of adequately explaining human learning, and therefore sought to research SDL as an internal psychological change in consciousness (Oddi, 1985). Oddi developed the instrument as a 24-item questionnaire, and where Guglielmino had focused on the readiness for SDL, looking into characteristics, attitudes, and abilities, Oddi designed her theoretical framework with the marked difference that her perspective

> […] focused on the personality characteristics of individuals whose learning behavior is characterized by initiative and

> persistence in learning over time through a variety of learning modes, such as the modes of inquiry, instruction, and performance. *(Oddi, 1986)*

During Oddi's initial studies, she identified three dimensions that she hypothesized were crucial to learners' propensity towards self-direction and which became foundational in the understanding on which she developed the OCLI. They were as follows.

Proactive drive versus reactive drive. "This dimension focused on the learner's ability to initiate and persist in learning without immediate or obvious external reinforcement" (Oddi, 1986, p. 98).

Cognitive Openness versus Defensiveness. "Salient characteristics of CO/D included openness to new ideas and activities, ability to adapt to change, and tolerance of ambiguity. The opposite pole included attributes such as rigidity, fear of failure, and avoidance of new ideas and activities" (Oddi, 1986, p. 99).

Commitment to Learning versus Apathy or Aversion to Learning. "Salient characteristics of CL/ AAL included the expression of positive attitudes toward engaging in learning activities of varying sorts and a preference for more thought-provoking leisure pursuits. The opposite pole included expressions of indifferent or hostile attitudes toward engaging in learning activities and reports of less engagement in activities commonly regarded as promoting learning" (Oddi, 1986, p. 99).

After extensive testing, Oddi had worked down her initial 100 items to the aforementioned 24 and concluded that the instrument had demonstrated satisfactory validity and reliability (Oddi, 1984, 1986). Oddi's and other scholars' effort to validate the OCLI are thoroughly reviewed in chapter 3 of this thesis and paper 1 (Clausen & Hansen, 2022). Even though Brookfield might have been wary of the appropriateness of Oddi's efforts to gauge self-direction with a standardized statistical instrument, her instrument is an attempt at measuring the kind of internal change in consciousness which he suggests should be labeled self-directed learning (Brookfield, 1985).

From the previous sections, we can see that SDL initially emerged from the field of adult learning through exploratory studies that sought to test the existence and extent of self-directed learning efforts. Subsequently, different conceptualizations

of self-directed learners were applied and discussed, some viewing it as a role students could adopt during a learning process and others as a set of characteristics that learners matured into as a result of an internal change of consciousness. Common for both conceptualizations is that they can be studied as resulting in a certain approach to, attitude towards, and behavior in, learning.

2.4 Conceptual critique of Rogerian SDL

In addition to the internal debates and criticisms brought to light by Brookfield and Mezirow about what the goals of SDL should be, there have also been fundamental critiques about the ontological and epistemological assumptions that underlie SDL. Servant-Miklos and Noordegraaf-Eelens challenged the Rogerian claim that self-directed learning encompasses emancipatory potential (Servant-Miklos & Noordegraaf-Eelens, 2021). Servant-Miklos and Noordegraaf-Eelens claimed that SDL rests on a fundamentally individualistic view of self and learning and that the current challenges of not only education, but society as a whole, are inadequately served by any approach based on such assumptions. Through an analysis of Carl Rogers' ontological foundation for SDL or the process of self-discovery, they concluded that the most extreme forms of self-direction in learning, Rogerian education, is so dependent on individualistic humanistic psychological assumptions that it warrants serious scrutiny and critique. They debated these assumptions, arguing against Freire and Vygotsky, to explore dialectic approaches to education and in conclusion suggested social-transformative education through problem-oriented project-based work. A central premise of Rogers' that the authors critique is that of the emancipatory potential of self-discovery; the notion that, if students are left to their own devices and teachers act only as facilitators, their innate quest for actualization and learning will eventually make them engage in what he sees as the only learning which *significantly influences behavior*, that of *self-discovered, self-appropriated learning* (Rogers, 1958, p. 4; Servant-Miklos & Noordegraaf-Eelens, 2021). Servant-Miklos and Noordegraaf-Eelens rejected the notion that SDL can live up to the Rogerian promise of emancipation through self-discovery, and instead contended that:

> At the end of the day, emancipation is not a purely collective event and must also imply autonomy of the individual. While offering emancipation without challenging the structural impediments to such does not work, neither does challenging structural issues without recognizing individual personhood. Personhood in social transformative education is recognised,

> valued and expressed in its contribution and participation to what 'could be'. *(Servant-Miklos & Noordegraaf-Eelens, 2021, p. 160)*

Servant-Miklos and Noordegraaf-Eelens thus suggested that the understanding of emancipation as an individualistic endeavor is inadequate to meet the needs caused by global social problems. They proposed the adoption of a problem-oriented, interdisciplinary, participant-directed educational approach, primarily implemented through the utilization of learning projects. Servant-Miklos and Noordegraaf-Eelens highlighted the Danish reformed university Roskilde University Center as the most thorough implementation of their suggested approach.

A point of contention is that the paper presupposes that the appeal of SDL is the promise of emancipation (Servant-Miklos & Noordegraaf-Eelens, 2021, p. 160). While this might be true for Rogers and some implementations of SDL, the primary focus for the vast majority of the research on SDL is on more practical features. Cyril Houle, Malcolm Knowles and Allen Tough are all far more concerned with what motivates adults to learn, what characteristics they exhibit, and how they go about learning (Houle, 1961; Tough, 1971; Tough & Knowles, 1985). That is not to say that the criticism brought forward is invalid or irrelevant, but rather that the type of Rogerian implementation of SDL that the authors appear to take aim at is rarely present in the field of research.

In the present thesis, SDL is examined as a set of characteristics that learners might possess, which makes them inclined to work independently and autonomously within the bounds of AAU PBL, mediated through the specific educational program that they are enrolled in. Discussing whether the students can be considered thoroughly emancipated, or if challenging structural issues should be a goal of education, is outside the bounds of this study, but Servant-Miklos and Noordegraaf-Eelens bring to light a relevant criticism of the underpinnings of SDL that should be considered more thoroughly if researching the Rogerian claims of emancipation through self-discovery.

2.5 SDL in problem-based learning

In the context of PBL, self-direction is often identified as a dual-faceted element: both as an inherent process and thus a pre-requisite for students and as a beneficial learning outcome (Hung et al., 2008; Leary et al., 2019). Students in PBL environments are actively encouraged to assume responsibility for their learning trajectories through participant-directed case studies or projects. The supervisors,

who are experienced experts from the student's chosen profession and selected with their project/case problem in mind, incrementally reduce their involvement over successive semesters (Dolmans & Schmidt, 2000; Loyens et al., 2008). PBL is intended to not only teach students professional domain knowledge, but also to teach them how to learn effectively by enhancing their ability to solve problems, navigate the knowledge of their chosen field, work autonomously, and evaluate and reflect on their practices and approaches (Ge & Chua, 2019; Savery, 2006). It has been highlighted by several researchers as an approach to learning that helps students become active and autonomous learners through activities rooted in real-world problems where students are themselves responsible for their learning (Hmelo-Silver, 2004; Savery, 2015).

A widely recognized advantage of PBL is that it facilitates a nuanced and comprehensive understanding of the subject matter under investigation. However, this depth of focus introduces an inherent limitation: the potential neglect of a broader knowledge base, given the high degree of specialization involved in project and case work. SDL is often perceived as ameliorating this issue, ensuring that students possess the tools necessary to identify and remedy gaps in their knowledge base (de Graaff & Kolmos, 2003).

Moreover, the role of collaborative group work in PBL has been pinpointed as a particularly effective means for nurturing robust SDL skills. This collaborative element aids in fostering competencies essential for formulating incisive questions and providing constructive feedback. Studies also indicate that PBL students are inclined to develop strategic plans for their work and assimilate an expansive array of new information into their problem-solving endeavors, granted that they are allowed to establish their personalized learning objectives (Hmelo & Lin, 2000).

In an extensive literature review, Blumberg sought to ascertain whether problem-based learners also exhibit characteristics of self-directed learners. She discovered that students engaged in problem-based learning (PBL) are notably more active users of libraries in comparison to their peers in traditional educational settings. Moreover, PBL students exhibited a proclivity for seeking a broader range of knowledge sources and deviating from teacher-prescribed literature, effectively self-directing their literature searches (Blumberg & Michael, 1992; Blumberg & Sparks, 1999). These students were found to have honed what Blumberg termed as "library skills" or self-directed information-seeking behavior. Additionally, PBL students were observed to deploy learning strategies that promoted deep-level learning, leading to an enhanced focus on comprehension over mere rote

memorization. Blumberg further noted that these strategic approaches to learning and subsequent reflection seemed to provide PBL students with an advantage in evaluating academic materials and structuring their work and studies (Blumberg, 2000). In a parallel vein, Evensen observed that some first-year students in a PBL environment displayed indicators of having developed competencies related to reflective learning, environmental adaptability, goal-setting, self-efficacy, and information-seeking strategies (Evensen, 2000).

Several empirical investigations have sought to elucidate the synergistic relationship between SDL and PBL. In a study conducted by Loyens et al., it was determined that PBL facilitates the development of various SDL competencies, aligning closely with Brookfield's conceptualization of SDL techniques. Specifically, the research demonstrated that students engaged in PBL utilized a more diverse array of resources and information tailored to their learning objectives compared to their counterparts in traditional educational settings (Loyens et al., 2008). These findings resonate strongly with the work of both Evensen and Blumberg, who have reported similar outcomes (Blumberg, 2000; Evensen, 2000).

Furthermore, Schmidt and Dolmans observed a progressive increase in self-reliance among PBL students over the course of their academic experience. These students displayed a diminishing dependence on formal lectures, increasingly favoring group discussions as a learning medium (Dolmans & Schmidt, 2000). Corroborating these observations, Kivela and Kivela conducted a study on PBL implementation in Hong Kong and found a similar trajectory. Initially, the students appeared reliant on teacher guidance; however, this dependency waned over time. By their second year, the students exhibited marked growth in self-direction and autonomy (Kivela & Kivela, 2005).

A notable challenge in integrating SDL within PBL pertains to less mature learners. Such individuals often encounter difficulties in engaging in self-directed activities and generally require a heightened degree of external scaffolding and structure (Hmelo-Silver, 2004; Knowles, 1980a; Tough & Knowles, 1985). A closely related concern is the observed tendency among these learners to exhibit limited reflectivity regarding their own learning processes. This lack of self-reflection is particularly problematic given that the ability to reflect has been identified as a pivotal factor in the development and modification of effective personal learning strategies (Evensen et al., 2001).

A challenge when doing research in PBL is that the terminology is highly contested and implementations of PBL vary greatly in scope and form (Chen et al., 2021; Servant-Miklos, 2020; Servant-Miklos et al., 2019). AAU PBL, a combination of a problem-based and project-organized approach, has continuously developed through a pragmatic adaptation based on a number of theoretical principles and perceived societal demands (Holgaard et al., 2020; A. Kolmos et al., 2004). In Denmark, the terminology of participant direction is often applied as a basis of how the project organized teamwork should be governed in PBL and other student-centered approaches (Boelt & Clausen, 2023; Illeris, 1974). Participant direction highlights the significance of a collaborative relationship among students, teachers, and, when relevant, additional participants, jointly steering the learning process (Illeris, 1981). At AAU, participant direction is situated within a structure in the form of curricula with semester themes, learning objectives, intended learning outcomes, and assessment criteria that take into account directions set by institutions such as government, industry, accreditation bodies, and the professional field the students strive to enter upon completing their education (de Graaff et al., 2016). Students themselves form teams in most semesters, through workshops where problems or overarching themes are suggested or defined by faculty or the students themselves, a process in which the students have extensive self-determination (Bundgaard et al., 2021; Clausen & Kolmos, 2019). The students then enter into a participant-directed collaboration with their supervisors within which they formulate problem formulations that serve as the starting point for their project work and direct the remainder of the typically semester-long projects (Sørensen, 2022).

2.6 Chapter summary

From this chapter, we can summarize that SDL is a contested terminology that encompasses perspectives on process, instruction, skills, techniques, and individual characteristics. Further, there are different approaches to how the enacted behavior of individuals, which might be seen as self-directed, is to be interpreted either as a set of skills and characteristics that they embody as part of a process of self-direction, or as a development of their consciousness because of maturation and/or critical awareness. At first glance, the lack of a uniform definition of the terminology, which has also been a recurring theme for central scholars in the field (Brockett, 1985a, 1985a; Brookfield, 1984, 1985; Fellenz, 1985; Garrison, 1997), might seem a more severe problem than it actually is. SDL as a research field has persisted despite the conceptual plurality and two factors stand out as central explanations.

First, in this examination of the historical literature it became clear that there are different motivations that influence the strains of research pursued and the conceptualization of SDL applied. As Mezirow reiterated from Habermas, there is a distinction between knowledge produced in the practical and in the emancipatory domain (Habermas, 1971; Mezirow, 1981). SDL research initially arose from adult education scholars with a distinct practical motivation and thus employed research designs that focused on understanding self-direction as expressed through intersubjectivity and communication. Conversely, some later scholars sought to develop emancipatory knowledge through research that focused on influences including culture, history, and biography. These scholars developed research efforts that sought to uncover the often taken-for-granted subconscious rationales that lie beneath and limit our actions, and thus applied a definition of self-direction that incorporated critical awareness of ideology and how it restricts and distorts the type of self-direction that the practical scholars research. The distinction from Habermas helps explain why these two related research avenues, to best serve their objectives, must necessarily apply different definitions of SDL, and why the debate over which ones "should" be applied persists (Servant-Miklos & Noordegraaf-Eelens, 2021).

Fellenz advanced the second point, that the conceptualization of SDL within the practical domain can vary, either being framed as a role assumed during the learning process or as a progression or maturation of an individual's psychological state. However, regardless of these differing interpretations, it is posited that the effects generated by these distinct conceptualizations can be subjected to parallel analytical approaches (Fellenz, 1985).

As for the relationship between SDL and AAU PBL, we can conclude that there are several studies that show correlations between involvement in PBL and the development of SDL or related concepts. There are, however, also studies that have shown no correlation between the two. Theoretically, self-direction is practiced during the supervisor-facilitated, participant-directed, problem-based, project-oriented teamwork that takes up the majority of the AAU student's time. During such collaborations, the students must overcome their differences and negotiate shared practices that (self) direct their work. To advance the understanding of the development of SDL in AAU PBL students, it was therefore chosen to pursue methods to gauge whether students become increasingly self-directed in their approaches to learning. Furthermore, methods were identified for analyzing and assessing whether these methods could be appropriately applied in this context.

3. To what extent can a measure such as the Oddi Continuing Learning Inventory (OCLI) give insights into SDL in problem- and project-based learning?

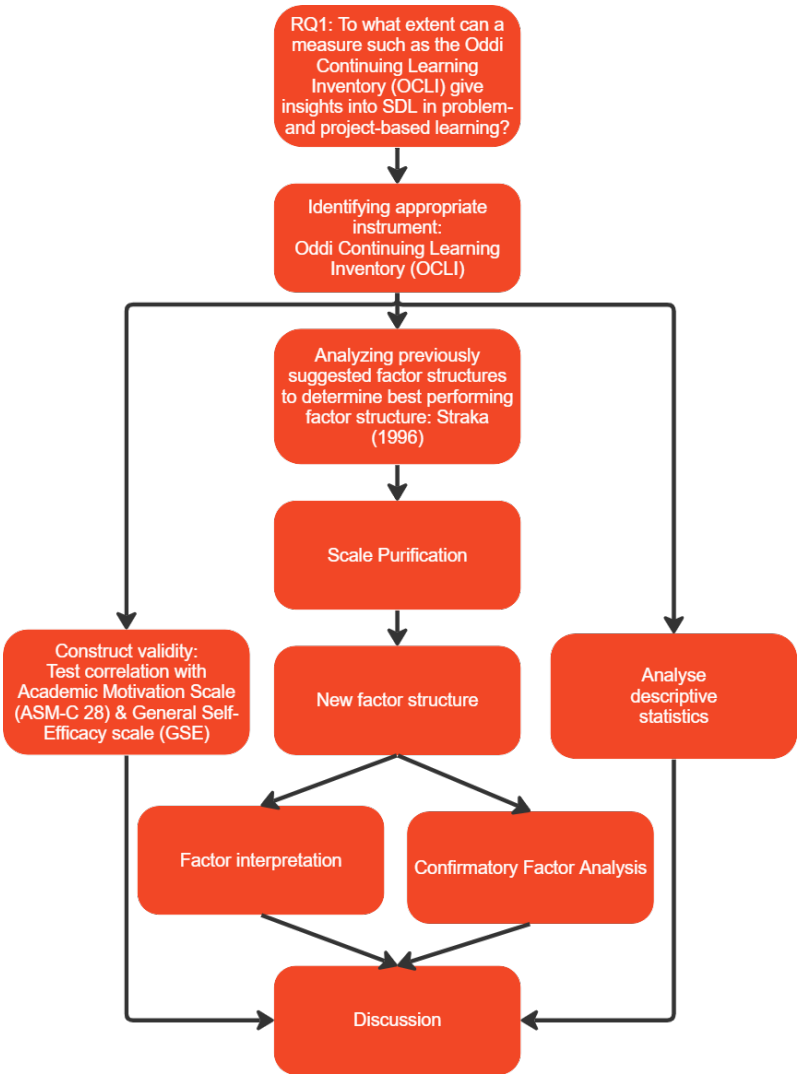

Figure 2. Outline of the process of phase two.

To answer the first research question, “To what extent can a measure such as the Oddi Continuing Learning Inventory (OCLI) give insights into SDL in problem- and project-based learning?”, the OCLI was revalidated on AAU PBL students. The initial findings were disseminated in the form of paper 1 and are further expounded upon in the present chapter. Due to word count limitations imposed by the journal, certain topics that were only briefly covered in paper 1 are discussed in greater detail herein.

An initial examination of relevant scientific literature was conducted to identify instruments capable of measuring an individual's inclination towards self-direction in learning. While several potential candidates emerged from this exploration, the decision to employ the OCLI was reached, as detailed in subchapter 3.2.

The OCLI is one of the most popular statistical instruments for measuring SDL and has already undergone extensive validation, which we will return to later in this chapter (Boyer et al., 2014; Han & Lee, 2009; Harvey et al., 2006; Oddi, 1984, 1985; Six, 1989; Straka, 1996). In the present thesis, an exploratory application of confirmatory factor analysis was conducted, marking the first such application to the OCLI. Additionally, the convergent validity of the OCLI was assessed through the inclusion of two other instruments in both data collection and subsequent analysis. A factor interpretation was also performed on the newly identified three-factor structure. Recommendations for future research endeavors, as well as limitations inherent to the study, were delineated.

The initial step involved translating the OCLI and the two instruments for assessment of its convergent validation, the Academic Motivation Scale (AMS) and the General Self-Efficacy Scale (GSE) into Danish. Each author conducted the translation process independently, and any discrepancies were reconciled through consultation with an external subject-matter expert. The preliminary Danish translation, along with the original English versions of the instruments, was then assessed by another external expert specializing in survey construction. Feedback from this revision was integrated to finalize the translated instruments.

Data collection was carried out electronically. Respondents were provided with an email containing a link to the questionnaire, subsequent to a brief presentation by one of the researchers during an in-person lecture. To mitigate potential bias, the presentation abstained from divulging specifics concerning the research subject. The rationale for this in-person lecture strategy was to enhance the response rate, considering the frequent receipt of surveys by students over the course of a

semester. Responses were collected from two academic cohorts at AAU: one comprising 82 individuals from sociology and another consisting of 77 from construction engineering. For validation objectives, it was imperative that these cohorts be somewhat representative of the target population for the instrument in question. Nonetheless, if participants were students within a similar cultural and educational context, the findings would be deemed applicable. The aggregate of 159 responses was imported into STATA16 for subsequent analysis (Statacorp, 2019).

Sociology	82
Construction engineering	77
Total	**159**

Table 1. Respondents' educational programs from paper 1 (Clausen & Hansen 2022).

Factor analysis is utilized in relation to multiple-indicator measures to assess the tendency of indicators to aggregate into coherent and distinct clusters. It is often used to allow for a more clear and meaningful analysis by diminishing the number of variables (Bryman, 2008). In the confirmatory factor analysis, we adhered to established thresholds for fit indices as benchmarks for the instrument's performance. Subsequently, we refined the scale incrementally, by removing variables, until these thresholds were met (Wieland et al., 2018). While alternative strategies could have been chosen, our primary objective was to assess whether the instrument aligned with current validation techniques. Thus, a conservative approach was adopted for this study. The primary objective was to ensure that the identified model met the thresholds of the selected fit indices, giving precedence to the performance of its statistical properties. Subsequent to this, the aim was for this process to yield a factor model that is both theoretically coherent and interpretable. Upon optimizing the OCLI to an adequately performing factor structure, we delved into factor interpretation and found that the refinement process had also yielded more theoretically unidimensional factors (Clausen & Hansen, 2022). Intuitively, by reducing the number of variables encompassed within a particular factor structure, one would expect the factors to gravitate towards unidimensionality, if the same number of factors is retained. However, our assertion is that the improvement to the interpretability of the resulting factors goes beyond what can attributed to this effect.

In addition to the confirmatory factor analysis described above, we further validated the OCLI by including two established statistical instruments that we hypothesized would correlate with the OCLI total score. Such a validation approach is common both for newly developed instruments and for established ones being

tested in cultural contexts distinct from the one in which it was developed and originally validated (Boyer et al., 2014; Cronbach & Meehl, 1955; Guglielmino, 1977; Oddi, 1984). Given the robust theoretical connection between motivation and self-efficacy to SDL, we opted for well-regarded measures of these constructs (Leary et al., 2019; Oddi, 1984; Schwarzer & Jerusalem, 1995; Vallerand et al., 1992).

The Academic Motivation Scale's college version (AMS-C 28) was selected to compare the OCLI with a contextually appropriate motivation metric. This decision was rooted in the consistently recognized interplay between self-direction and motivation within SDL research, especially in relation to PBL, and because Oddi herself invited more studies of the relationship the OCLI and motivation (Leary et al., 2019; Oddi, 1984, p. 171). The inclusion of the GSE was motivated by the theoretical association of self-efficacy with SDL and its documented empirical correlation (Boyer et al., 2014). Our hypothesis assumed covariance between the OCLI and these instruments, a relationship we subsequently confirmed (Clausen & Hansen, 2022, p. 357).

The last part of the analysis was the factor interpretation. After having generated factors through an exploratory application of confirmatory factor analysis and scale purification, we were left with factors we were certain lived up to the contemporary statistical benchmarks we had chosen to apply, but had yet to judge whether any meaningful theoretical interpretation of them was possible. Factor interpretation is a subjective process that requires specific theoretical knowledge and careful consideration. The interpretation, which is extensively covered in paper 1, resulted in three factors: internal locus of control, ability to be self-regulating, and avidity for learning.

The study ultimately found that the OCLI can be applied to gain instights into SDL in a context such as AAU PBL with certain limitations in mind, as elaborated in paper 1 (Clausen & Hansen, 2022). Findings indicate that the OCLI measures stable underlying dimensions related to SDL and that the methodology applied to revalidate it could advantageously be used to revitalize other instruments of similar potential.

3.1 Quantitative research in adult education

Another important impetus for reevaluating and applying statistical instruments like the OCLI is rooted in an examination of adult education literature from the 1970s and 1980s. A substantial number of studies in which such instruments were developed, validated, and applied for empirical analysis were published in that period. A closer inspection of research from this era thus unearthed several rigorous instrument developments and validations that appear to have been largely neglected in subsequent research endeavors. Trends in academic publications in this field substantiate that qualitative studies have outnumbered quantitative ones, a pattern that has persisted for several decades following the field's transition from a predominance of theoretical publications to empirical work (Boeren, 2018; Clair, 2011; Taylor, 2001).[1]

Despite advances in information technology, computational power, and fit indices for scale development, there has been a noticeable scarcity of attempts to rejuvenate and utilize previously developed instruments (Brown, 2015). This oversight becomes particularly relevant in the context of emerging educational technologies like learning analytics and learning management systems, which often lack involvement from educational scholars and could benefit from incorporating statistical instruments rigorously developed and validated by such scholars (Williamson, 2019).

It is not the intention here to advocate for a general departure from qualitative research methods. Rather, the argument posits that embracing a more diverse methodological landscape could engender unique and varied perspectives (Daley et al., 2018).

3.2 Choosing the OCLI

As mentioned in the previous chapter, several statistical instruments have been developed and applied to measure SDL or related constructs since the 60s. In this subchapter, the arguments for choosing the OCLI, as also touched upon in paper 1, paper 2, and the previous chapter, will be elaborated (Clausen, 2021; Clausen & Hansen, 2022). Several instruments have been developed to attempt to measure SDL, but as with so many research efforts in the field, the instruments each adhere to their own conceptualization of SDL. A relatively new statistical instrument measuring self-direction in learners is the Personal Responsibility Orientation to

[1] Stats on the development are elaborated in paper 1.

Self-Direction in Learning Scale (PRO-SDLS) (Stockdale, 2003). The instrument builds upon the Personal Responsibility Orientation (PRO) conceptualization of SDL developed by Brockett and Hiemstra (Brockett & Hiemstra, 1991; Stockdale & Brockett, 2011). Their model integrates various perspectives to encompass the personal characteristics and attributes of learners, while also providing systematic guidelines for SDL as a process. In their characterization of self-directed learners, the authors emphasized the individual's inclination towards assuming responsibility and taking ownership of their own learning process. Notably, their theory acknowledges both the pivotal role of learners' behavior and approach, while also underscoring the influence of the social context (Brockett & Hiemstra, 1991). While the PRO-SDLS is relatively new, its conceptualization of SDL as both a learner characteristic and a process make it less appropriate for our study than the OCLI, which views SDL solely as a learner characteristic expressed through attitudes and behaviors.

As mentioned in the historical overview, both SDLRS and OCLI have been used extensively since their conceptions and a relatively recent meta-review found that the two instruments constitute more than 85% of all applications of statistical instruments to measure SDL (Boyer et al., 2014). West and Bentley attempted to test the OCLI and SDLRS´s predictive capabilities by distributing the instruments alongside a survey about participation in SDL activities. They gathered 810 responses from schoolteachers and found that while none of the instruments showed great promise in predicting the teachers' general level of participation, the OCLI performed better than the markedly longer SDLRS. Another result of the study was the remarkable lack of correlation between the two SDL instruments; they reported that only 15% (r=.39) of either scale could be statistically explained by its relationship to the other (West & Bentley, Jr., 1991). This result is, however, contested by another study which also compared the SDLRS and OCLI and found vastly different results, reporting that 69% (r=.83) of the variance on either scale could be explained by their relationship (Jude-York, 1993). While it would have been interesting to include the SDLRS in the validation study to further examine the performance of the translated version of the OCLI, it was not possible to do so as the SDLRS is exclusively distributed through a private platform and funds exceeding those allocated for the thesis were needed to purchase tests (Guglielmino, n.d.).

Extensive efforts have been previously made to test the validity of the OCLI in several different ways. Oddi herself tested its convergent, discriminant, construct, and factor validation and others have made several studies testing it as well (Boyer

et al., 2014; Clausen & Hansen, 2022; Harvey et al., 2006; Oddi, 1984, 1985; Six, 1989; Straka, 1996). The validation studies have been reviewed in paper 1, but to supplement here we will provide a more thorough overview of the previous construct and factor validations of the OCLI (Clausen & Hansen, 2022).

3.3 Previous validation studies of the OCLI

Multiple endeavors aimed at validating the OCLI have already been conducted. These validation efforts can be categorized into two primary types: factor validations, which examine the factor interpretations of the instrument, and construct validations, which assess the extent to which the instrument accurately measures its intended construct.

3.3.1 Factor validations

Upon developing the OCLI, Oddi performed an exploratory factor analysis that disclosed a three-factor structure, deviating from the theoretical dimensions originally proposed. Initially, she identified five factors, but deemed them theoretically uninterpretable, opting for an oblique rotation three-factor model applying a minimum factor loading of 0.5, explaining 45.7% of the total variance. Oddi interpreted the first factor, comprised of 15 items, explaining 30.9% of the total variance, as "*a general factor relating to several other elements of self-directed continuing learning, such as ability to work independently and learning through involvement with others*". The second factor, "*ability to be self-regulating"* is comprised of three items, all reverse coded, explaining 8% of the total variance as. The last factor, consisting of four items, explaining 6.8% of the total variance, was interpreted as *"avidity for reading".* Two items (21 and 24) failed to load satisfactorily on any factor (Oddi, 1985, 1986). While Oddi's validation of the instrument was mathematically sound, there were a few issues, especially related to the size of the first factor, including so large a portion of the items, making it hard to interpret, a fact that she also remarked upon in her conclusions (Oddi, 1984).

Six investigated whether Oddi's factor structure would replicate across other samples, applying what he called the "Gorsuch model," comparing two sets of derived factors from different samples to analyze to which degree the correlate. Six examined Oddi's original sample and a sample of business administration and secretarial science students from a business college in central New York. Six found that Oddi's structure was largely replicated, except for three items (7, 8, and 13) that failed to load adequately on any factor. However, the factor loadings were

very similar to those found in Oddi's original sample, being only slightly above the popular threshold in Oddi's sample and slightly below in Six's. The analysis indicated that the factor structures exhibited co-variation on individual factors ranging from 0.93 to 0.99, thereby successfully demonstrating the replicability of the OCLI across different samples (Six, 1989).

Straka conducted a confirmatory factor analysis to test Oddi's factor structure's stability on a different cultural sample by replicating the procedures of Oddi and Six on a German sample. To this effect, he collected replies to a German translation of the OCLI from 548 students at Bremen University in Germany. Straka's analysis showed that the OCLI performed slightly worse with the German sample, attaining a lower reliability. The factor structure obtained from the oblique rotation, applying an extraction criterion of three factors, yielded a slightly different model than did Six and Oddi. Most notably, the explained variance dropped to 32%, and items 3, 4, 6, 7, 14, and 23 migrated from factor 1 to 3. This made factor 1 much less complicated to interpret as it moved most of the items related to SDL's social aspects, thereby to a certain degree achieving the goal set by Oddi to attain factors that are theoretically easier to interpret. Straka's first factor encompasses ten items, explains 17% of the total variance, and is interpreted as "*self-awareness of one's autonomy and self-efficacy in conjunction with reading behavior*". Straka's second factor replicates Oddi's, but also includes item 24, which, like the rest of the included items, is reverse coded. It explains 8% of the total variance, and Straka interprets it as the "*ability of self-evaluating his/her achievement".* The third factor explains 7% of the total variance, is comprised of eight items, and is interpreted as a combination of reading avidity and social dimensions of SDL (Straka, 1996).

Harvey et al. conducted an exploratory factor analysis on 250 medical students at the University of Toronto. They identified both a three-factor structure closely resembling Oddi and Six's and a four-factor structure with an even better fit. Both factor structures were then tested in both oblique and orthogonal rotations alongside a three-factor structure created, according to Oddi's original theoretical dimensions, through confirmatory factor analysis. The obliquely rotated four-factor solution provided the best model fit, explaining approximately 40% of the total variance, split almost evenly across the four factors. The first factor, consisting of six items, is interpreted as "*learning with others*". The second, consisting of eight items, as "*learner motivation/self-efficacy/autonomy*". The third and fourth factors consist of five items each and are interpreted as "*ability to be self-regulating*" and "*reading avidity*" (Harvey et al., 2006).

Han & Lee also conducted an exploratory factor analysis in which they, similarly to the approach in paper 1, conducted scale purification of the OCLI, resulting in a three-factor model, which including 15 items, and reached commonly applied thresholds for several fit indices (Han & Lee, 2009).

Even though extensive factor validations have been conducted before the present study, none of them employ the exploratory application of confirmatory factor analysis that is presented in paper 1. The previous studies taken into consideration, there are also remaining questions as to the stability of the underlying dimensions of the OCLI given the variation between the similar factor structures of Oddi, Six and Straka and the newer efforts of Harvey et al. and Han & Lee (Han & Lee, 2009; Harvey et al., 2006; Oddi, 1984; Six, 1989; Straka, 1996).

3.3.2 Construct validations

Oddi initially tested the construct validity of the OCLI by arguing that SDL should, based on theoretical assumptions, either not correlate, correlate positively, or correlate negatively with other given theoretical constructs. She then identified tried and tested instruments measuring the constructs, distributed them alongside the OCLI, and deduced whether her assumptions of positive, negative, or no correlation held true through statistical analysis.

The Leisure Activity Survey (LAS) was used to assess the OCLI's ability to predict participation in educational activities. As presumed, it obtained a significant positive correlation, providing evidence of construct validity.

The Internal-External scale (I-E scale) was applied to measure the respondents' locus of control. Oddi assumed that self-directed, continuous learners would typically express an internal locus of control, believing that their success in life was highly contingent on their behaviors and actions. However, the analysis did not show any significant correlation between OCLI and I-E scale scores.

The Shipley institute of living scale (Shipley) supplied a short estimate of IQ, expressed through vocabulary and abstraction. Oddi assumed, based on SDL literature, that there would be no significant correlation between the scales, and the analysis confirmed this to be accurate, implying construct validity.

Lastly, Oddi used the Adjective Checklist (ACL) and several subscales to test more complex constructs. The Affiliation subscale (ACL-Aff), which measures an individual's inclination to engage in personal friendships, was tested. The

Endurance subscale (ACL-End) measures an individual's inclination towards dutybound, conscientious, and productive attitudes towards work, against those of more easily distracted and changeable individuals. The Self-Confidence subscale (ACL-S-Cfd) measures attributes associated with confidence in achieving goals and having high aspirations. The Change subscale (ACL-Cha) quantifies an individual's affinity towards complex challenges (Gough & Heilbrun, 1983). Oddi argued that based on SDL literature, positive correlations with all four subscales should be assumed, that self-directed learners would be inclined to engage in more friendships, work conscientiously, have self-confidence, and welcome complex challenges. The tests affirmed all presumptions except for the ACL-Cha which showed no significant correlation (Oddi, 1984). The newest study to assess the construct validity of the OCLI is a meta-analytical review by Boyer et al. that analyses the research on SDL and related constructs for effective workplace learning. They identified studies implying that SDL has been discovered to correlate with internal locus of control, motivation, support, self-efficacy, and increased performance. Specifically, the OCLI has been observed to have associations with self-efficacy, support, and increased performance. However, it is worth noting that the linkage between SDL and motivation remains inconclusive, necessitating further research (Boyer et al., 2014). This sentiment is mirrored by Oddi, who has raised questions concerning the construct validity of the OCLI. Oddi recommends that the instrument be concurrently administered with another measure of motivation for more comprehensive evaluation (Oddi, 1984). Similarly, Guglielmino has expressed reservations about the Self-Directed Learning Readiness Scale (SDLRS), advocating for additional investigation into its relationship with motivation (Guglielmino, 1977).

3.4 Findings

Results of the OCLI can be interpreted as an expression of three underlying latent dimensions of SDL: internal locus of control, ability to be self-regulating, and avidity for learning. The instrument can be utilized to gain insights into the students' inclinations towards self-direction in learning as expressed through the three factors, at a statistical level, but can advantageously be supplemented by other methods to create a more insightful perspective and evaluation of students' SDL.

The relatively unidimensional theoretical nature of the factors in our validation and the performance in terms of contemporary statistical tests in confirmatory factor analysis speaks to the instrument's quality. The extensive efforts to test the construct validity should also be considered. We tested the OCLI's performance and

correlation against well-established tests for academic motivation and self-efficacy, related concepts that have been highlighted by Oddi's own and subsequent validation efforts, and found what one would expect of an instrument reliably measuring SDL (Clausen & Hansen, 2022; Harvey et al., 2006; Oddi, 1984, 1985). Oddi also conducted substantial and thorough testing of the construct validity of the instrument, purporting both discriminant and convergent correlations based on the instrument and its theoretical underpinnings, which in all but one case were verified (Oddi, 1984, pp. 141–170).

As mentioned in the discussion in paper 1 and in the limitation's subchapter above, there are obvious potentials in improving the OCLI, like updating some of the questions to more contemporary practices or addressing the limitations of our validation effort. Some of the question formulations are embedded in a technological setting far removed from that of present day students, while others use wording and phrases that now have different connotations than when they were originally conceptualized.

As per our discussion and conclusion in the article, I recommend that the OCLI, like all similar statistical instruments, be applied with its limitations in mind, and its results interpreted with modesty. If the purpose of the study is, like ours, explanatory, then it is highly recommended to follow up with qualitative studies, substantiating and elaborating on the results of the application of the OCLI.

Answering the research question posed, "To what extent can a measure such as the OCLI give insights into SDL in a participant-directed educational setting such as AAU PBL?", we have presented extensive findings that speak both to the advantages and disadvantages of applying an instrument such at the OCLI. In the following section and paper 1, the limitations of the study are discussed and, taking those into consideration, it is evident that the OCLI can be applied to give insights into SDL in AAU PBL students. There are limits to the possible insights gained from statistical instruments attempting to measure constructs as complex as SDL and we have attempted, through statistical analysis and interpretation, to outline the extent of the possible insights gained from applying the OCLI. The results show that the OCLI performs as expected of an instrument that measure stable underlying dimensions of SDL, and that even though there are potentials for improvements, the OCLI can be applied to gain insights into SDL as expressed through attitudes and behaviors in a participant-directed educational setting such as AAU PBL.

3.5 Limitations

In conducting a validation study such as the one delineated in the current chapter, acknowledging study limitations is crucial for multiple reasons. Such transparency serves to identify potential weaknesses that could be addressed in future research, and provides readers with the necessary context to assess the generalizability and validity of the findings. While the study offers valuable insights, it is accompanied by inherent limitations that warrant consideration.

3.5.1 Sample size

The question of appropriate sample size for confirmatory factor analysis has evolved beyond merely adhering to absolute numerical minimums; a range of factors can now be considered in determining a suitable sample size. Nonetheless, some literature supports a minimum recommended ratio of between 10:1 and 20:1 for cases to free parameters (Kyriazos, 2018). Given that the present study involves a sample size of 159 students and the OCLI comprises 24 items, the study does not meet these standardized ratio recommendations. Although some scholars advocate for discarding such rules of thumb, such as the 10:1 or 20:1 ratio (Brown, 2015), in the absence of alternative justifications, it must be concluded that the validation study would have been strengthened by a larger sample size.

3.5.2 Generalizability

It is imperative to note that the sample employed in this study is exclusively composed of enrolled university students in Denmark, thus imposing limitations on the generalizability of the findings. Future endeavors aimed at validating the OCLI would benefit from utilizing a more demographically diverse sample. Such a sample could offer greater variance in age and other demographic factors, thereby enhancing the validity of the OCLI for broader populations. Given the current sample, it is reasonable to assume that attributes such as socioeconomic background, educational level, and age are more homogenous than would be observed in a general population.

3.5.3 Reliability

Another limitation of this validation which could be addressed in future studies is that of reliability. Reliability refers to the precision or accuracy of a given measurement, attempting to answer how well an instrument actually measures what it purports to measure (Brown, 2015). There exist multiple methodologies for addressing reliability concerns. One such approach involves assessing the stability of the measure through a test-retest paradigm. An alternative method, which was

employed in the current study, includes the use of related measures—namely the AMS and the GSE—to evaluate construct validity. While incorporating an instrument like the SDLRS would have been informative, constraints related to funding and the instrument's distribution model rendered its inclusion infeasible. In addition to the SDLRS, numerous other instruments could have enriched the study. However, given that the respondents were students volunteering their time during lectures and that data collection was contingent upon the cooperation of their instructors, it was both ethically and practically imperative to limit the number of included instruments. Subsequent validation efforts would benefit from the inclusion of additional measures and a test-retest application where feasible.

4. Do AAU PBL students become more self-directed in their approach to learning?

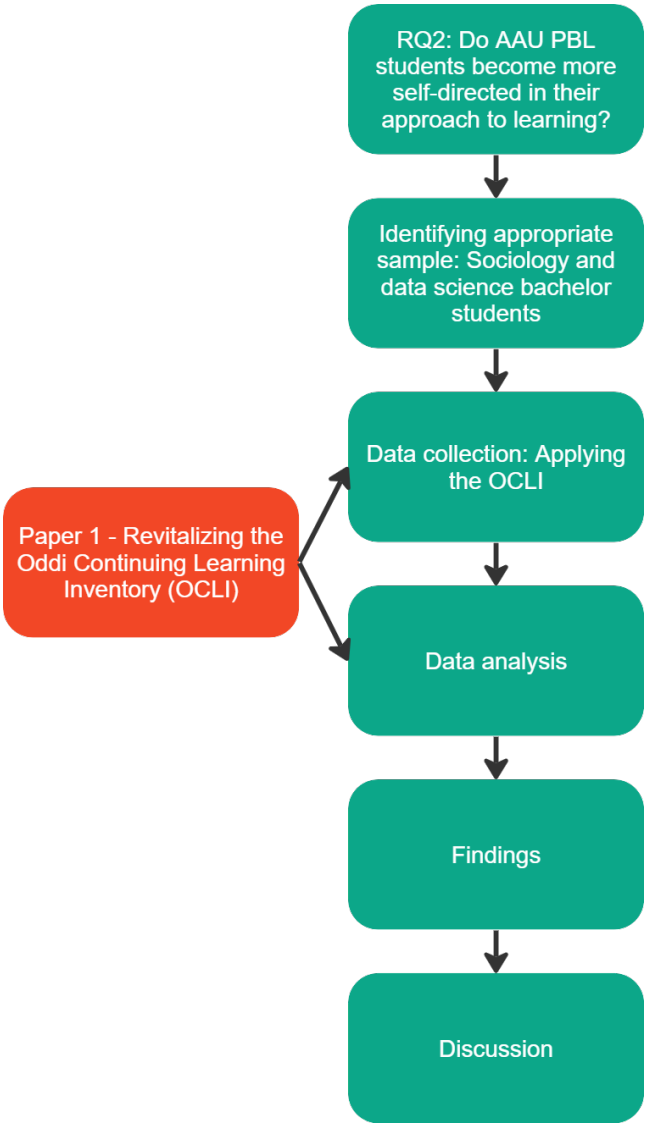

Figure 3. Outline of the process of phase three with contribution from paper 1 (Clausen & Hansen 2022).

Upon validation of the OCLI, it becomes feasible to initiate the investigation into the extent to which students at AAU become more self-directed over the course of their studies. While the relationship between SDL as PBL is often highlighted in educational literature, empirical investigations have produced ambiguous results. Though there are many studies and theories, like the ones reviewed in chapter 2.5, that support the existence of the purported relationship, there are other studies that have failed to find clear evidence for PBL students becoming more self-directed (Harvey et al., 2003; Litzinger et al., 2005). Given this discrepancy, it was considered beneficial to first ascertain whether students enrolled in AAU PBL programs indeed exhibit increased self-direction as they advance in their studies.

To answer the second research question, "Do AAU PBL students become more self-directed in their approach to learning?", the newly-validated OCLI was therefore applied to students enrolled in the sociology and data science bachelor programs at AAU. The findings are disseminated in paper 2 and will be elaborated on in this chapter (Clausen, 2021).

Data collection was conducted in a similar fashion to how it was done during the effort to validate the OCLI, as reported in chapter 3 and paper 1 (Clausen & Hansen, 2022). Respondents were approached during a lecture with consent from their lecturer and were given a brief introduction to the study, while avoiding going into specifics about the research subject to avoid potential bias. After the introduction, the students received an email with a link to the questionnaire and were afforded time to answer during the lecture. Respondents were recruited from different stages of their bachelor's program (first, second, or third year). The respondents were enrolled in their second, fourth, or sixth semester and were approximately one month into the semester at the time of the data collection.

	Responses	% of total	Response rate
First year	101	25,25%	67,3%
Second year	203	50,76%	58,5%
Third year	96	24%	37,4%
Total	400	100%	53,1%

Table 2. Response rates of students according to semester from paper 2 (Clausen 2021).

The analysis utilizes the factor structure established in paper 1 (Clausen & Hansen, 2022). Furthermore, the paper includes scores obtained from two-tailed significance tests to ascertain the statistical significance of the observed differences. To validate the findings, commonly accepted thresholds for

interpreting p-values are applied. Additionally, results with p-values that closely approach these thresholds are discussed when relevant. Moreover, other appropriate measures, such as Levene's test for equality of variances, are reported and adjusted for when necessary.

The analysis uncovered three developments during the students' time at AAU that are thoroughly presented in paper 2 (Clausen, 2021), and briefly depicted below.

OCLI-total. The students had a general rise in OCLI-total score, the development was consistently positive, and statistically significant between the first and third year as well as between the second and third year.

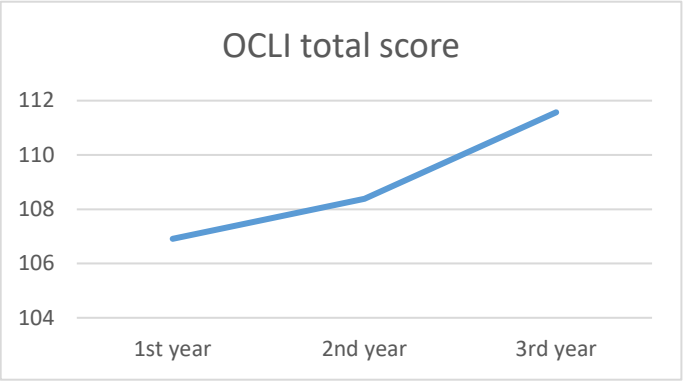

Figure 4. OCLI total scores for all respondents (n=400).

Ability to be self-regulating. There was a statistically significant rise in the students' ability to be self-regulating between the first and the second year.

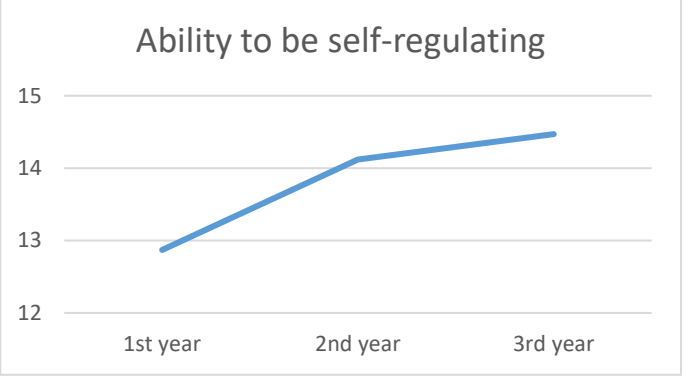

Figure 5. Ability to be self-regulating factor for all respondents (n=400).

Internal locus of control. There was a statistically significant rise in the students' internal locus of control between the second and third year.

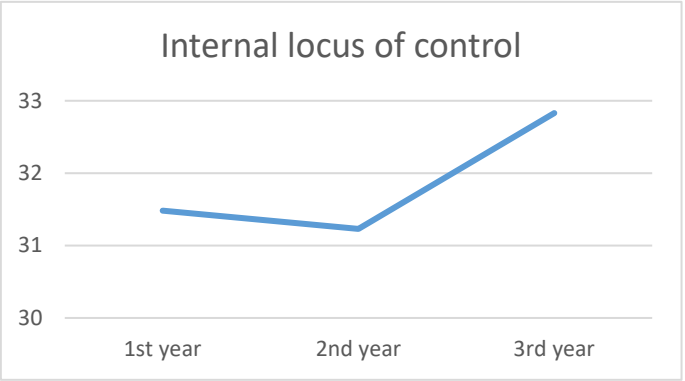

Figure 6. Internal locus of control factor for all respondents (n=400).

The analysis thus supported the purported relationship between SDL and PBL, showing that, according to the conceptualization applied in the OCLI, the students that were further into their education at AAU self-reported behaviors and attitudes more conducive to SDL than did their junior peers. The findings are elaborated and discussed in the following section and in paper 2 (Clausen, 2021).

4.1 Findings

Based on the OCLI, the students in the study show a general rise in their inclination towards self-direction in learning, as expressed through self-reported attitudes and behaviors, as they progress through their bachelors' studies. This rise is, in and of itself, interesting because there has been conflicting evidence as to PBL's ability to make students more self-directed (Blumberg, 2000; Harvey et al., 2003; Sungur & Tekkaya, 2006). Taking into account the findings, and acknowledging the limitations delineated in the subsequent section and in paper 2, the conclusion can be drawn that the students participating as respondents in this study have demonstrated increased self-directedness in learning, as conceptualized by the OCLI. The self-reported attitudes and behaviors of the students indicate a trend toward greater self-direction as they advance in their academic journey within an AAU PBL framework. Thus, the findings support the notion that AAU PBL students become more self-directed in their approach to learning.

Additionally, the findings show that the observed increase in SDL attitudes and behaviors can be categorized into two separate and distinct developments. The initial development occurs between the first two data points, approximately six to 18 months into the educational experience. During this period, there is a

statistically significant increase in the factor interpreted as "ability to be self-regulating". The subsequent development is observed between the 18th and 30th month, wherein there is a statistically significant increase in the factor denoted as "internal locus of control".

The progression observed in student development aligns with existing literature on SDL, particularly as conceptualized by Knowles in his exposition of andragogy. Knowles positioned pedagogy and andragogy and their associated learner assumptions along a continuum (Knowles, 1970). An interpretation grounded in this perspective might suggest that the observed increase in SDL reflects the transition of learners from a pedagogical paradigm to an andragogical one. This shift implies a decreasing reliance on teacher guidance, validation, and external motivators. Conversely, learners would exhibit an increasing predilection for self-regulation, skepticism towards teacher authority, and a yearning for intrinsic motivation and control. However, in subsequent discussions, Knowles et al. (2005) underscored that a successful transition to SDL necessitates initial guidance and facilitation. Rogers (1969) also posited that for transitions from traditional to more self-directed learning environments to be successful and minimally anxiety-inducing, learners must gradually acclimate to the increased responsibility for their learning. The slight observed decline in internal locus of control from the first to the second year, though not statistically significant, could be interpreted as corroborating such an understanding. This finding is also consistent with prior research that has shown that students take some time to evolve from relying on their lecturers and groups to manifesting greater independence and intrinsic motivation, showcasing a heightened internal locus of control (Kivela & Kivela, 2005). Other empirical research has also indicated that abruptly placing students in a self-directed learning environment without clear expectations and ample preparation can adversely impact student retention and learning (Dunbar & Dutton, 1972; Margarones, 1961; McCauley & Mcclelland, 2004).

At AAU, the students transition to a learning environment where the relation to the teacher becomes more akin to that with a facilitator than a teacher and the students must rely much more heavily on themselves and their peers. Additionally, they have to contend with supervisors whom they, because of the degree of specialization required in semester-long projects, are often more knowledgeable than in the particular niche of their projects (de Graaff, 2016; A. Kolmos et al., 2008). At AAU, a part of facilitating the transition is embodied in the inaugural semester's PBL skills course. This course acquaints students with the AAU

approach, equipping them with strategies to navigate problem-based projects and prompting them to introspectively assess their past and present learning practices. An integral element of this transition is the gradual transfer of responsibility to students for directing their projects. This methodical transfer is meant to steadily empower the student as they progressively take charge of their own learning (A. Kolmos et al., 2008, 2019). The findings, with limitations in mind, suggest that such a transition is overall successful at AAU, with students demonstrating growth in self-regulating behaviors and inclinations, as well as an increased predisposition towards SDL.

One interpretation of the findings and the above-mentioned notions and structures at AAU is that the rise in students' ability to be self-regulated is in part facilitated by their introduction to PBL through their supervisors and the PBL skills course. Subsequently, building upon successful project experiences, they may then cultivate confidence in their proficiency with the AAU approach, gravitating towards a more internal locus of control. Such an interpretation aptly captures the chronological progression evident in our findings.

4.2 Limitations

There are certain additional limitations to the study that it is essential to address to ensure that the results can be understood and interpreted transparently and to offer directions for future research efforts.

4.2.1 Assumptions of homogeneity

One issue with using successive generations of students instead of successive measurements derived from the same cohort of students, as one would in a traditional longitudinal design, is that the findings rely on an assumption of homogeneity. The validity of our results hinge on the assumption that there are not any major differences between the three generations which effect their OCLI score. We assume a degree of homogeneity across the generations so that when we perceive a difference between two of them, what we perceive is a result of them being at different stages of their education, not a result of the generations being heterogeneous when they began their education at AAU. We have no reason to believe that there are any such differences between the generations, but it is essential to be aware that our findings rest on that assumption.

4.2.2 Selection bias

One limitation in the research design that cannot be readily tested is selection bias. Self-directed learning (SDL) is frequently cited in literature as both a prerequisite for and a beneficial outcome of problem-based learning (PBL). If an inclination toward SDL is a precondition for success in AAU's PBL environment, it is plausible that students with lower proclivities for SDL may disproportionately constitute the dropout population. Such a selection effect could potentially explain or amplify findings similar to those presented in paper 1 (Clausen, 2021). Some previous research suggests that this bias should be cautiously considered when examining PBL (Ertmer et al., 1996; Hmelo-Silver, 2009).

Another form of selection bias that warrants consideration pertains to lecture attendance. As outlined at the outset of this chapter and in paper 2, the OCLI was distributed to all students enrolled in a specific semester but was presented during a physical lecture. It is conceivable that a correlation exists between students who attend lectures and those who generally perform well and exhibit self-directedness. Such an effect would skew the response rate towards the most self-directed students, given that the students are more likely to respond to the questionnaire if they are in attendance for the presentation. Alternatively, an inverse relationship between lecture attendance and self-directedness could also be posited. In this scenario, the most self-directed students might increasingly choose to forgo lectures, perhaps as a manifestation of their self-directed approach to learning. Such students may perceive that their learning objectives can be more effectively met through alternative means, thereby opting out of traditional lecture attendance.

For future research, a longitudinal study design tracking the same cohort of PBL students could offer valuable insights. Such a design would facilitate the exploration of whether the OCLI total score significantly predicts dropout rates. It would also be instructive to correlate OCLI scores with students' grades to ascertain any relationship between academic performance and self-directedness. Incorporating additional demographic variables like gender and age into the study could also enhance the richness of the findings.

In a study of this nature, the employment of regression analytical techniques would be advantageous for capturing and quantifying interactions among various variables. Conducting a regression analysis on longitudinal data, collected from the same cohort of students over time and incorporating background variables,

academic performance, and dropout rates, could substantially enhance both the generalizability and validity of the study's findings. This methodological approach would allow for a more nuanced understanding of the interplay between self-directed learning, academic performance, and other relevant factors, thereby offering a more robust framework for interpreting results.

5. How do students practice SDL in problem- and project-based teamwork at AAU?

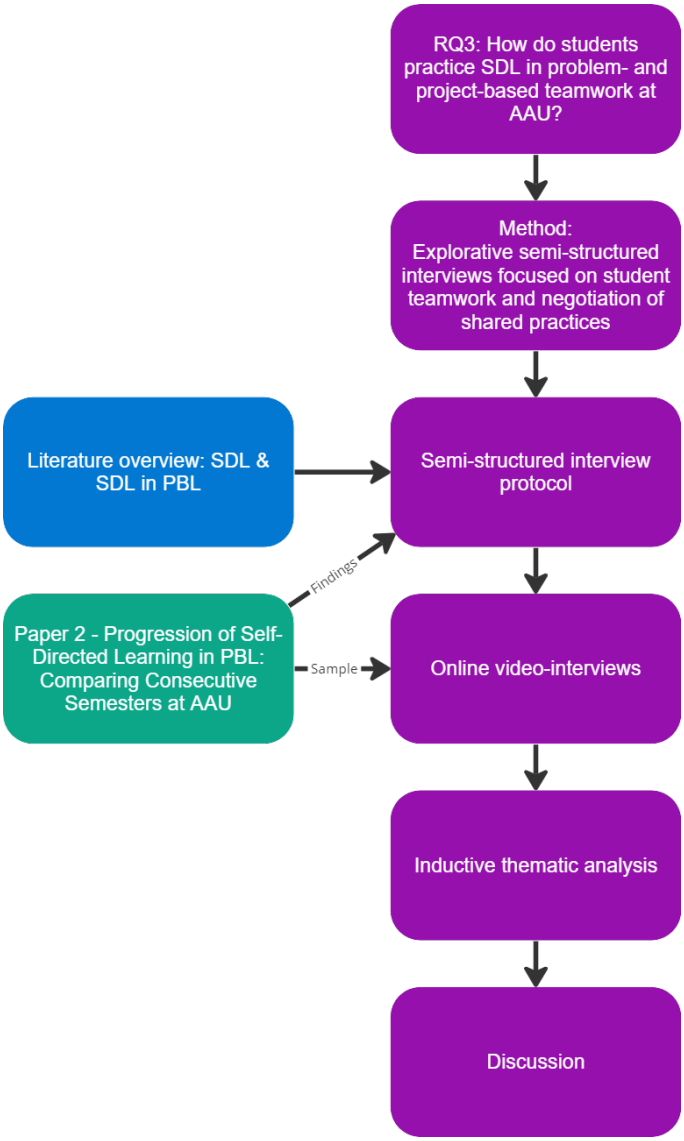

Figure 7. Outline of the process of phase four with contributions from phase one and paper 2 (Clausen 2021).

Although the prior study utilizing the OCLI suggested students became more self-directed and provided limited insights via factor analysis, it did not substantially address the previously identified “black box” concerning student self-direction in the participant-directed teamwork of AAU PBL (Sørensen, 2022). To tackle this issue, the third research question of this thesis was formulated. To address the third research question posed in this thesis, namely, “How do students practice SDL in project-oriented problem-based teamwork?”, a series of semi-structured interviews was conducted with students from the same sociology and data science cohorts examined in the prior empirical investigation. This study was conceptualized as an endeavor to delve deeper into the intricacies of students' self-direction practices during their extended, often semester-long, project-oriented teamwork, a hallmark of the AAU PBL framework (Clausen, 2023; Clausen & Kolmos, 2019; A. Kolmos et al., 2004) .

At the beginning of each semester, students form teams and are paired with faculty supervisors, through a process in which the students have extensive self-determination (Bundgaard et al., 2021; Clausen & Kolmos, 2019). However, beyond the occasional insights gleaned during supervisory sessions, the inner workings of these student teams largely remain elusive to researchers, representing a metaphorical "black box" (Sørensen, 2022). The conducted interviews aimed to illuminate this otherwise obscured domain, shedding light on the nuances of self-directed learning within the context of team-based projects. Through the interviews, insights are garnered regarding the students' practices. More specifically, these insights reflect individual students' perceptions of their practices as they opt to share them with the researchers.

During the interview process, a primary consideration was safeguarding against any inadvertent influence that might arise from the interviewer's pre-existing beliefs or expectations, thereby potentially causing participants to align their responses accordingly. To counteract this possibility, a progressively structured interview approach was adopted, whereby the structure gradually intensified as the interview proceeded. The intent behind this methodology was to curtail potential bias and guarantee a representation of the participants' viewpoints and lived experiences with high fidelity. The interview protocol, carefully crafted to serve this purpose, drew from a synthesis of theoretical understanding and empirical findings related to SDL and PBL, complemented by insights derived from paper 2 and chapter 4 (Clausen, 2021). Given the constraints imposed by the national COVID-19 lockdown during the data collection phase, in-person interactions were untenable.

Consequently, interviews were facilitated online via MS Teams, an institutionally endorsed digital platform.

Data was analyzed using thematic analysis, following the guidelines by Braun and Clarke (2006). This method aims to pinpoint and interpret patterns within qualitative data, focusing on themes that capture significant aspects related to the research question rather than their frequency. Rather than adhering to

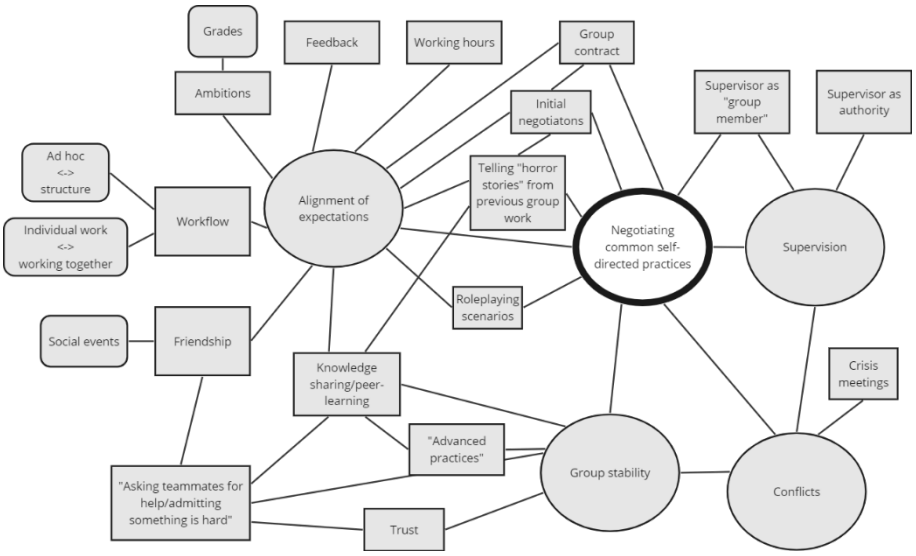

Figure 8. One of several maps produced in phase 3 of the thematic analysis. outlines themes, topics and connections of the data (Clausen 2023).

predetermined theories, the theme selection employed an inductive approach, allowing the data itself to guide the analysis. This approach acknowledges that findings are contextually constructed and aren't detached from researchers' perceptions (Galletta & Cross, 2013a). Braun and Clarke proposed six broad, interrelated phases for thematic analysis that incrementally categorize and narrow down the themes for presentation (Braun & Clarke, 2006). They are as below.

1. Data Familiarization. In this step, data immersion is achieved by reviewing interviews both audibly and visually during transcription. During such review, preliminary ideas for themes start to surface.

2. Generating Initial Codes. Here, significant interview segments are coded, aiming to convert raw information into analytically pertinent data. Care is taken to

maintain the richness of the original statements, and initial interconnections between segments are noted.

3. Searching for Themes. This phase clusters coded data into potential overarching themes. Figure 1 provides a visualization of the preliminary thematic organization formulated at this juncture.

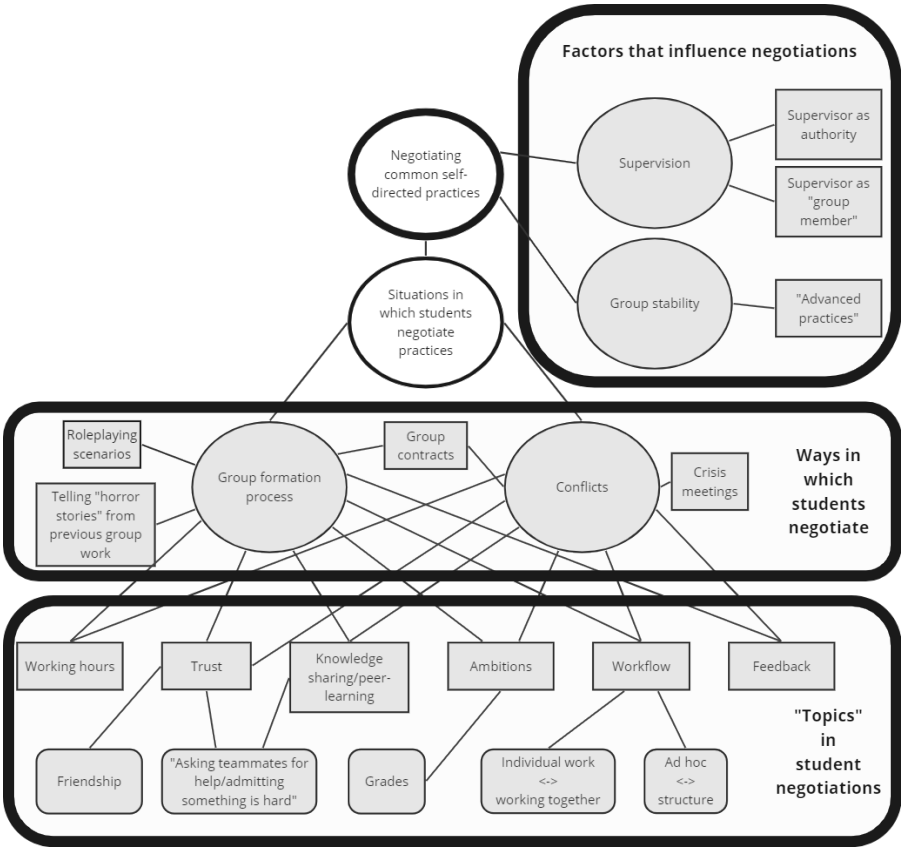

Figure 9. Revised map produced in phase 4 of the thematic analysis after revisiting data and demarcating overarching topics (Clausen 2023).

4. Reviewing Themes. This phase comprises two levels. Initially, the relevance of data segments to the proposed themes from the preceding phase is reassessed. Then, the whole dataset is examined for the fit of these candidate themes. The intertwining nature of students' accounts often complicates clean thematic demarcation. Multiple iterations of thematic maps are developed, like the one in Figure 2. A pivot in analysis direction is evident as emphasis shifts to the "modes of student negotiations", highlighted as central to team practice formation. Some subthemes from previous frameworks found resonance within the newly emphasized themes.

5. Defining and Naming Themes. This phase fine-tunes the themes. Each is rigorously evaluated for alignment with the data narrative, representation of individual segments, and ensuring minimal overlap. Figure 3 showcases the finalized overarching theme and its subordinates.

6. Producing the Report. The final phase focuses on coherently elucidating the themes. Key extracts that best convey each theme's essence are chosen. An initial broad view is provided, succeeded by detailed narratives from a select few students to underscore the nuanced, context-specific nature of their accounts. This approach, rooted in the guidance of Braun & Clarke (2006, p. 93), ensures a comprehensive yet intricate depiction of student experiences.

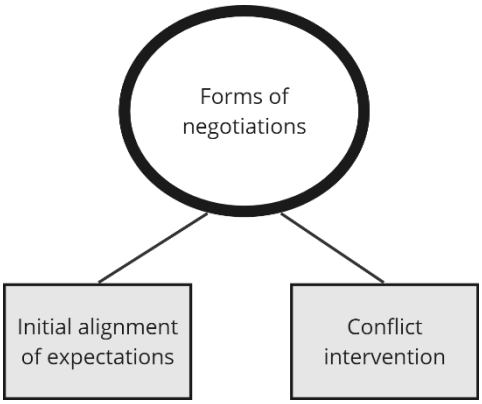

Figure 10. Final map of the thematic analysis displaying the overarching and subsumed themes (Clausen 2023).

The theme of initial alignment of expectations involves deliberate negotiations undertaken in the early days of each teamwork, to establish common practices among the team members. These negotiations often encompass the coordination of a wide variety of teamwork elements. While some teams delve into detailed rules and guidelines for future collaboration, others focus on sharing past team experiences. They discuss negative encounters and successful strategies, often emphasizing general principles like mutual respect and trust instead of explicit rules. These agreements are sometimes formalized in written contracts, whereas others are verbal understandings. The study points towards several specific

individual student developments as integral to the team being able to engage in successful negotiations.

The analysis found that the students often also engage in negotiations of practice through conflict intervention, which makes up the second theme. While many conflicts are simple disagreements resolved through compromise or majority voting, those requiring deeper intervention are often rooted in interpersonal or contextual issues. Teams frequently find themselves revisiting and renegotiating facets of their practices in circumstances where the precipitating conflict appears to stem from factors seemingly unconnected to the actual elements that are being renegotiated. Such conflicts, in essence, can act as catalysts, prompting deeper reevaluations and adjustments of their shared practices. The findings will be elaborated further in subchapter 5.2.

5.1 Semi-structured interviews and conceptual determinism

This research employs a semi-structured interview approach, cognizant of the historical context of empirical studies on SDL, which have displayed a contentious track record with structured interviews. Tough (1971) pioneered a method involving rigidly structured interview protocols that became a mainstay in SDL studies for an extended period. While this method enhanced the comparability of studies, it also bore the peril of conceptual determinism. Essentially, this means the inherent understanding embedded in the interview protocol could inadvertently shape the perspectives of its participants and, given the widespread use of the protocol, could influence the overarching research domain (Brookfield, 1981; Caffarella & O'Donnell, 1988; Tough, 1971). To circumvent this potential pitfall, yet still ensure the coverage of topics previously identified as vital, a semi-structured interview protocol was crafted, one that progressively and consistently introduced structure as each interview progressed.

In this research, the interview guide was informed by topics such as project management, collaboration, professionalism, alignment and management of varied expectations, interactions with supervisors, study habits, and more. However, the inclusion of these topics was not intended to impose a predefined structure or to dictate the course of the conversation. Instead, these topics were organized into a checklist, serving as a reference towards the latter parts of the interviews. This was to ensure all crucial elements were touched upon but did not dominate or direct the conversation from the outset. During the initial stages of the interview, students were granted freedom, encouraging them to bring forth and emphasize

components and experiences they deemed pertinent. Thus, the interviews commenced with more open-ended queries, designed to spur the students into introspection about their methods of group collaboration, their approach to project undertakings, and their educational progression. This approach sought to capture a holistic understanding of the students' experiences, uninfluenced by potential biases of the interviewer, while still ensuring that all critical areas of interest were eventually addressed. The interview protocol in included as appendix A and a English translation as appendix B.

This methodology ensures that informants' responses are not constrained by the potential subjective and theory-laden interpretations of the interviewer (Galletta & Cross, 2013b). Following the initial, loosely structured segment of the interview, the protocol provides a comprehensive overview of topics discussed and indicates areas that might warrant further exploration in subsequent stages (Galletta & Cross, 2013c). Such a strategy proves particularly valuable when exploring complex issues, especially in situations where the interviewer possesses substantial knowledge, and it is imperative to ensure this knowledge does not unduly influence the participants. As Galletta and Cross remarked:

> As a hybrid method, the semi- structured interview can be structured into segments, moving from fully open- ended questions toward more theoretically driven questions as the interview progresses. (…) A key benefit of the semi-structured interview is its attention to lived experience while also addressing theoretically driven variables of interest. (Galletta & Cross, 2013a, p. 24)

A potential difficulty with this interview format, in contrast to a more structured approach, arises from the need for the interviewer to monitor which topics have been addressed in the less structured segment and the extent to which each topic has been elaborated upon.

5.2 Findings

From the thematic analysis, we can see that the students primarily negotiate their collective teamwork practices in two different ways during the problem-based project-oriented teamwork of AAU PBL; through 1) initial negotiations and 2) conflict intervention. They engage in initial negotiations in the beginning of each semester as they enter newly formed teams and align expectations for the coming

teamwork. The study indicates that specific personal developments are essential to the success of such initial alignments of expectations. They include the following.

1. By participating in teams and collaborating with a diverse group of peers, students have discerned the existence of a more extensive range of approaches and practices than they initially perceived.
2. Students have discovered the value of proactively addressing potential conflicts through comprehensive alignment of expectations. Furthermore, they recognize the importance of negotiating joint practices and approaches at the commencement of a project when collaborating with a new team.
3. By observing and experiencing the approaches of their peers and previous teams, students have acquired insightful self-awareness concerning their own practices, strengths, weaknesses, and preferences.
4. Students have acquired methods to communicate their preferences proficiently to new team members and subsequently establish joint practices. Such understanding can be attained through the adoption of novel vocabulary, techniques, exercises, or other procedures by which the individual team members' expectations and preferences are uncovered.

The second method discerned, wherein students undertake deliberate negotiations of collaborative practices, is through conflict intervention. A notable observation regarding these conflict interventions was the apparent discrepancy between the issues instigating the conflict and the topics addressed during the intervention. Although teams addressed perceived disagreements believed to be the root of their conflict, they also frequently revisited other components of their shared practices that seemingly bore no direct relation to the prevailing conflict.

5.3 Limitations

5.3.1 Individual interviews or focus groups

A recognized limitation of this study is its reliance on individual team members recounting events that inherently involve the entire team. An alternate methodology could have entailed conducting focus-group interviews with full student teams. While individual interviews allowed participants to provide more in-depth accounts of their personal experiences and feelings—and granted interviewers greater flexibility to adapt to these narratives—using focus groups might have yielded a more comprehensive understanding of students' perspectives. However, introducing focus groups would also have exposed the

discourse to pre-existing group dynamics, potentially constraining the range of opinions and experiences participants felt comfortable sharing (Bryman, 2008). Alternatively, informants could have been interviewed on subsequent semesters, providing succeeding snapshots of current practices.

5.3.2 Deliberate negotiations or ongoing alignments

In the present study, findings reveal what can be termed as deliberate negotiations wherein students consciously aim to establish a common practice or agreement. Nonetheless, drawing from other research on similar cohorts, it's noted that students described the delineation of roles, setting expectations, project management, and related factors as an ongoing, adaptable process in perpetual flux (Boelt et al., 2023). Consequently, when assessing the implications of the findings of the present research, it's crucial to recognize that while the study sheds light on aspects of deliberate negotiations, the extent to which the established practices are consistently modified and reinterpreted remains undetermined. Examining such adaptation and subconscious social alignments might greatly enhance the richness of our knowledge of how the shared practices of the students are formed.

Future research endeavors should focus on delving deeper into the developmental processes identified by students as critical for engaging effectively in practice negotiations within participant-directed teamwork. Moreover, longitudinal studies, potentially employing observational methods or conducting a series of interviews over time, could yield more comprehensive insights. Such an approach would also allow for a closer examination of the dynamics of negotiation and adaptation of shared practices, which, as established by prior research, constitute an ongoing and evolving process.

6 Discussion

In this chapter I will discuss and conclude on the research and results presented in this thesis and elaborate on the implications for our understanding of SDL in problem- and project-based learning. This thesis has attempted to address the overall question:

What can be learned from using self-directed learning to research problem- and project-based learning?

Chapter 2 of this thesis attempts to frames the research by presenting a historical literature overview on SDL and SDL in PBL. This chapter shows that SDL has been conceptualized in several ways, seemingly according to the goals of the particular research effort in which it is applied. The absence of a uniform theoretical framework for understanding SDL has been a persistent concern over the course of its existence (Brockett & Hiemstra, 1991; Brookfield, 1984, 1985; Fellenz, 1985; Garrison, 1997; Oddi, 1987). However, owing to the diverse array of objectives inherent in research endeavors relying on a characterization of SDL, a plurality of definitions persists as they each serve different objectives and interests. In the context of PBL research, SDL has predominantly been conceptualized as an inherent personal trait or a collection of competencies that students refine throughout their education. Within the framework of AAU PBL, participant-directed student projects progressively evolve towards greater student autonomy. Consequently, student self-direction increasingly becomes a prerequisite for participation and success.

6.1 Answering the research questions

In the three papers and their supplementary chapters in this thesis the three following research questions have been pursued:

1. To what extent can a measure such as the Oddi Continuing Learning Inventory (OCLI) give insights into SDL in problem- and project-based learning?
2. Do AAU PBL students become more self-directed in their approach to learning?
3. How do students practice SDL in problem- and project-based teamwork at AAU?

To answer the first research question, an appropriate statistical instrument was identified, validated, and its performance accessed. The efforts refined the instrument, the OCLI, through the process of scale purification, until a structure that adhered to thresholds for commonly applied fit indices emerged. After scale purification and refinement, the instrument performed satisfactorily. Further, a new factor interpretation with more theoretically unidimensional factors improved future understandings based on the instrument. Furthermore, the results demonstrate that the OCLI, when applied in an AAU PBL context, alongside other statistical instruments measuring related concepts, performs as expected, thereby supporting its validity in assessing stable underlying constructs. Our findings provide support for applying the OCLI as a means of obtaining insights into students' inclinations towards self-direction in learning as expressed through their attitudes and behaviours. However, it is important to acknowledge that there are certain limitations and potentials for improvements to the instrument that should be considered when drawing conclusions based on the results. Overall, the dissertation's key contributions with regards to research question 1 can be summarized as:

- A statistical validation of the OCLI that support the understanding that this instrument can be applied to gain insights into students' attitudes and behaviours towards SDL, but also highlight shortcomings of the instrument and makes suggestions to improve it.
- A methodological approach to statistical instrument validation that leverages modern advancements in computational power and statistical techniques to ease and improve the process of statistical validation. This approach could advantageously be applied to validate other statistical instruments that, while developed several decades ago, are the culmination of thorough theoretical and rigorous methodical instrument development processes.

To address the second research question, the newly validated OCLI was administered to AAU PBL bachelor students in sociology and data science. The study sought to determine if these students exhibited increased self-direction during their tenure in a project-oriented problem-based learning setting at AAU. The results revealed an overall increase in the students' OCLI scores from their first to fifth semester, reinforcing the notion that they indeed developed a stronger inclination towards self-directed behaviours and attitudes in learning. Beyond the aggregate OCLI scores, factor analysis identified two statistically significant and

discrete trends: an enhancement of students' ability to be self-regulating between the first and second year, and an increase in their internal locus of control from the second to the third year. Key contributions with regards to research question 2 can thus be summarized as:

- Application of the OCLI with AAU students which corroborate the hypothesis that students engaged in AAU's problem- and project-based learning environment exhibit an increased propensity towards self-directed learning.
- The observed increase in students' inclination towards self-direction in learning can be partly attributed to two distinct developmental phases and developments. The first, occurring between the first and second academic years, is characterized by an enhanced ability to self-regulate. The second phase, between the second and third years, is marked by a notable increase in their internal locus of control.

While contributions to research question 1 and 2 are important and relevant, they do little to illuminate the actual practices of the students. The third research question attempts to address this through a qualitative study of students' experiences of teamwork in their first years at AAU. SDL is such a multifaceted concept that it intersects with almost all facets of student practices within education. However, specifically, within the AAU PBL framework, students' self-direction is predominantly manifested during participant-directed, problem- and project-based teamwork, which accounts for half of their ECTS credits and, as self-reported, takes up the majority of their study time (Clausen & Kolmos, 2019; A. Kolmos et al., 2004). The findings indicated that the students develop shared self-directed practices for teamwork primarily through two different forms of negotiation. The students developed a myriad of different ways of negotiating and aligning expectations, but also highlighted certain developments that they deemed crucial for being able to successfully engage in the process. Key contributions regarding research question 3 can thus be summarized as:

- The thematic analysis of student interviews regarding collaborative practices within AAU's problem- and project-based teamwork revealed two primary approaches to negotiation of shared practices: an initial alignment of expectations at the onset of team activities and subsequent renegotiation during conflict resolution interventions.
- The study highlights that certain personal development is crucial for successful expectation alignment in team collaborations. Key

developments include: recognizing a wider range of approaches through diverse team interactions, understanding the importance of addressing potential conflicts early and negotiating joint practices at project onset, gaining self-awareness of personal strengths, weaknesses, and practices by observing peers, and developing communication methods to express preferences to new team members. This involves adopting new vocabulary, techniques, and exercises to uncover each member's expectations and preferences, facilitating the establishment of shared practices.

6.2 Implications for practice and future research

This thesis's findings hold the potential to both inform practice and stimulate further research. The subsequent section outlines several key areas where these contributions might be most significant.

A general recommendation for future research, emanating especially from the empirical results of papers 2 and 3, is to investigate the replicability of these findings in diverse educational contexts. Specifically, the application of the OCLI in various settings warrants further exploration. This could include examining more traditional university environments, as well as in institutions with different PBL models or other SDL-intensive learning methodologies. Additionally, applying the OCLI across various study programs at AAU, where PBL implementations may vary, could yield insightful comparisons.

Parallel inquiries could be extended to the findings from paper 3. Investigating whether students in other teamwork-focused educational settings identify similar factors as pivotal for successful practice negotiation. Another aspect worth exploring is how the duration of teamwork influences students' approaches and whether variations in time frames result in differing negotiation and collaboration strategies.

6.2.1 Transition and scaffolding

A recurrent challenge in educational systems employing SDL-intensive methodologies, such as AAU's, concerns managing the transition from traditional, more passive instruction to active, more student-centered learning. Rogers (1969) posited that such a paradigm shift could increase student anxiety, and he advocated a gradual transfer of responsibilities to alleviate such stress. This perspective was reinforced by later studies, which also emphasized the importance

of appropriate scaffolding in facilitating this transition (Barrows, 1988; Hung, 2011; Knowles et al., 2005; Margarones, 1961; McCauley & Mcclelland, 2004; Savery, 2015). Moreover, Knowles et al. (2005) attributed significant dropout rates in adult education to the challenges associated with transitioning to SDL and lack of appropriate scaffolding.

Therefore, while the findings from the present study suggest that the students at AAU become more self-directed as they progress in their studies, it is critical to consider whether this comes at the cost of heightened anxiety and dropout rates.

A comparison of first-year dropout rates at AAU with other Danish universities over the past three years, where data is available, reveals that AAU's figures are similar to the national average (Uddannelses- og Forskningsministeriet, 2023). These data, while multifactorial and of course not solely indicative of the impact of PBL or SDL, do not suggest that AAU's PBL model has exacerbated student dropout rates. In forthcoming research initiatives, a key inquiry should be to determine if students at Aalborg University (AAU) encounter greater levels of anxiety during their transition to higher education compared to students from other Danish universities. A comparative analysis involving Roskilde University would be particularly insightful, given its implementation of a project- and problem-oriented educational model that bears similarities to the PBL approach at AAU.

	AAU	DK Average
2019	11,1%	10,9%
2020	12,2%	11,6%
2021	12%	11,7

Table 3. First year drop-out rates of AAU and average across comparable educational institutions from 2019, 2020 & 2021 (Uddannelses- og Forskningsministeriet, 2023).

Given the frequently cited drawbacks of SDL-intensive educational frameworks in terms of the difficulties of managing the transition of students into it, and the apparent success of AAU in this regard, further investigation into AAU's first-year scaffolding/support mechanisms is also merited.

The marked improvement in in the students' "ability to be self-regulating" between the first and second academic years and the following significant improvement in their "internal locus of control" from the second to the third, as reported in paper 2, could also warrant further investigations. The initial rise could be interpreted as attributable to the influence of the PBL skills course, which appears to bolster the foundational competencies required for SDL. Subsequently, the continuous

engagement and success in problem- and project-based teamwork over several semesters likely fortifies students' confidence in their capability to effectively navigate and operate within this educational framework, causing the rise in “internal locus of control” between the second and the third year of study. While such an explanation might seem plausible, further investigations should be conducted, evaluating the PBL-skills course as well as other elements that scaffold the transition of new student into AAU PBL. Presently, the mandatory PBL skills course offered in the first year (Kolmos et al., 2019) and the establishment of semester-long teams are factors that might help alleviate the issues of transition and warrant further investigations. The semester-long teams, initially formed to support project work, may also function similarly to study groups. Within these teams, members have the opportunity to assist each other, collectively navigate the challenges of transitioning to a new educational environment, and potentially create a supportive social infrastructure. Such a dynamic could play a pivotal role in alleviating the anxiety commonly associated with adapting to the PBL model.

As such, case studies of individual study programs to analyse the scaffolding and support structures in place to facilitate the transition to PBL, could reveal much about what alleviates the potential anxiety and heightened dropout rates found in other studies of transitions to SDL-intensive educational frameworks. Further research is especially warranted on various elements integral to the educational model, including the implementation of semester-long teams, the PBL-skills course, and the pedagogical training provided to teachers and supervisors, among others. Explorative studies with the purpose of more fully outlining the scaffolding done in regard to the transition to PBL at AAU would also improve our knowledge of these mechanisms. Further, critical studies could further substantiate if the transition is in fact scaffolded appropriately at AAU or if the relatively average first semester dropout is the consequence of other factors. Such inquiries have the potential to yield insights beneficial not only to AAU but also to other institutions employing or considering similar SDL paradigms.

6.2.2 Digitalization of education and statistical instruments

In an era characterized by the proliferation of learning management systems, learning analytics, artificial intelligence, and an ever-present trend towards the digitalization of education, some educational scholars have also advocated caution (Gyldendahl Jensen, Clausen, et al., 2022; Gyldendahl Jensen, Dau, et al., 2022; Hung, 2023; Selwyn, 2011; Williamson, 2019). Some emphasize the scarceness of engagement from researchers well-versed in didactics and pedagogy during the

design phase of software intended to bolster learning. Moreover, they argue that technological constraints often overshadow pedagogical and didactic considerations during the design-phase.

One possible remediating factor to this predicament is the revalidation, adaptation, or creation of statistical tools that could be integrated into platforms, such as those for learning analytics. Numerous such tools are meticulously designed, rooted in pedagogical theories, and undergo relentless testing and revalidation processes. This study, specifically paper 1 and chapter 3 in this thesis, underscores the feasibility of validating the OCLI within contemporary educational contexts. While the OCLI instrument exhibits certain limitations that must be critically acknowledged during its application, it exemplifies the potential of tools, which have been meticulously developed, to provide insights into intricate facets of modern educational settings. Given the advancements in computational capabilities, digital data collection, and sophisticated statistical software, it is arguably more feasible now than ever before to conceive, validate, and deploy statistical tools, as well as evaluate their suitability and validity in diverse settings.

Thus, while the mere implementation of these statistical tools may not fully address the challenges introduced by the ongoing digitalization of education, they possess the potential to enhance insights, practices, and decision-making processes. This enhancement can be achieved by incorporating the rich theoretical insights upon which some such instruments are founded.

6.2.3 Longitudinal research

One notable constraint of the statistical investigation delineated in paper 2 and expounded in chapter 4 (referenced in section 4.2 of this thesis) is the absence of a longitudinal dimension. A longitudinal research design, tracing the developmental trajectories of the same cohort of students over an extended period, would significantly enrich the interpretive depth of the findings. It would facilitate a robust analysis of attrition patterns, affirming whether the observed augmentation in OCLI scores could be partially attributed to the dropout of students with lower inclinations for SDL, rather than an absolute increase in self-directed learning tendencies among the population.

Moreover, such a methodology would allow for the integration of additional variables — including academic achievement, age, gender, group dynamics, and socioeconomic factors — into the analytical framework. Employing a regression

analysis to account for these multifaceted interactions could substantially bolster the interpretive power of the OCLI application and, by extension, the substantive validity of the ensuing conclusions.

7 References

Barrows, H. S. (1986). A taxonomy of problem-based learning methods. *Med Educ*, *20*(6), 481–486.

Barrows, H. S. (1988). *The tutorial process*. Southern Illinois University School of Medicine.

Blumberg, P. (2000). Evaluating the Evidence That Problem-Based Learners are Self-Directed Learners: A Review of the Literature. In D. H. Evensen & C. E. Hmelo-Silver (Eds.), *Problem-based Learning—A Research Perspective on Learning Interactions* (pp. 199–226).

Blumberg, P., & Michael, J. A. (1992). Development of self-directed learning behaviors in a partially teacher-directed problem-based learning curriculum. *Teaching and Learning in Medicine*, *4*(1), 3–8. https://doi.org/10.1080/10401339209539526

Blumberg, P., & Sparks, J. (1999). Tracing the evolution of critical evaluation skills in students' use of the Internet. *Bulletin of the Medical Library Association*, *87*(2), 200–205.

Boelt, A. M., & Clausen, N. R. (2023). Participant Direction. In A. Kolmos & T. Ryberg (Eds.), *PBL in a Digital Age* (pp. 39–52). Aalborg Universitetsforlag.

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*.

Boeren, E. (2018). The Methodological Underdog: A Review of Quantitative Research in the Key Adult Education Journals. *Adult Education Quarterly*, *68*(1), 63–79. https://doi.org/10.1177/0741713617739347

Bosch, C., & Goede, R. (2019). *Self-directed learning: A conceptual overview* (pp. 1–36). https://doi.org/10.4102/aosis.2019.BK134.01

Boyer, S. L., Edmondson, D. R., Artis, A. B., & Fleming, D. (2014). Self-Directed Learning: A Tool for Lifelong Learning. *Journal of Marketing Education*, *36*(1), 20–32. https://doi.org/10.1177/0273475313494010

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brockett, R. G. (1983). Self-Directed Learning and the Hard-to-Reach Adult. *Lifelong Learning: The Adult Years*, *6*(8), 16–18.

Brockett, R. G. (1985a). A Response to Brookfield's Critical Paradigm of Self-Directed Adult Learning. *Adult Education Quarterly*, *36*(1), 55–59. https://doi.org/10.1177/0001848185036001007

Brockett, R. G. (1985b). Methodological and substantive issues in the measurement of self-directed learning readiness. *Adult Education Quarterly*. https://doi.org/10.1177/0001848185036001002

Brockett, R. G., & Donaghy, R. C. (2005). Beyond The Inquiring Mind: Cyril Houle's Connection to Self-Directed Learning. *Undefined*. https://www.semanticscholar.org/paper/Beyond-The-Inquiring-Mind%3A-Cyril-Houle%E2%80%99s-Connection-Brockett-Donaghy/4036cb6937d52289718d10c34ecd35d003ea65ad

Brockett, R. G., & Hiemstra, Roger. (1991). *Self-direction in adult learning: Perspectives on theory, research, and practice*. Routledge. https://eric.ed.gov/?id=ED359423

Brookfield, S. D. (1981). The Adult Learning Iceberg: A Critical Review of the Work of Allen Tough. *Adult Education (London)*, *54*(2), 110–118.

Brookfield, S. D. (1984). Self-Directed Adult Learning: A Critical Paradigm. *Adult Education Quarterly*, *35*(2), 59–71. https://doi.org/10.1177/0001848184035002001

Brookfield, S. D. (1985). Self-directed Learning: A conceptual and methodological exploration. *Studies in the Education of Adults*, *17*(1), 19–32. https://doi.org/10.1080/02660830.1985.11730445

Brown, T. A. (2015). *Confirmatory factor analysis for applied research* (Second edition). The Guilford Press.

Bryman, A. (2008). *Social research methods* (3. ed). Oxford University Press.

Bundgaard, S. B., Dahl, B., Krogh, L., & Ravn, O. (2021). *Exploring PBL Group Formation Processes*. Aalborg Universitetsforlag.

Caffarella, R. S. (1985). A Checklist for Planning Successful Training Programs. *Training & Development Journal*, *39*(3), 81.

Caffarella, R. S., & O'Donnell, J. M. (1988). Research in Self-Directed Learning: Past, Present and Future Trends. In H. B. Long (Ed.), *Self-directed learning: Application and theory.* University of Georgia.

Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin*, *56*(2), 81–105. https://doi.org/10.1037/h0046016

Chen, J., Kolmos, A., & Du, X. (2021). Forms of implementation and challenges of PBL in engineering education: A review of literature. *European Journal of Engineering Education*, *46*(1), 90–115. https://doi.org/10.1080/03043797.2020.1718615

Clair, R. S. (2011). Writing ourselves into being: A review of the Canadian Journal for the Study of Adult Education/La Revue Canadianne pour l'Étude de l'Éducation des adultes. *Canadian Journal for the Study of Adult Education*, *23*(2), Article 2.

Clausen, N. R. (2021). Progression of Self-Directed Learning in PBL: Comparing Consecutive Semesters at AAU. *Journal of Problem Based Learning in*

Higher Education, *9*(1), Article 1. https://doi.org/10.5278/ojs.jpblhe.v9i1.6373

Clausen, N. R. (2023). A little bit of trouble: Negotiating collaborative practices in student-centered teamwork. *Interdisciplinary Journal of Problem-Based Learning*.

Clausen, N. R., & Hansen, C. D. (2022). Revitalizing the Oddi Continuing Learning Inventory. *International Journal of Learning, Teaching and Educational Research*, *21*(5), Article 5. https://ijlter.org/index.php/ijlter/article/view/5026

Clausen, N. R., & Kolmos, A. (2019). PBL Future work report 2: Preliminary findings of the student survey. Presentation of frequencies on faculty level. In *PBL Future work report 2* [Report]. Aalborg Universitet.

Coolican, P. M. (1973). *The learning styles of mothers of young children*. Syracuse University.

Creswell, J. W. (2013). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 4th Edition* (4th editio). SAGE Publications, Inc.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (Fifth edition). SAGE.

Cronbach, L. J., & Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological Bulletin*, *52*, 281–302. https://doi.org/10.1037/h0040957

Daley, B. J., Martin, L. G., & Roessger, K. M. (2018). A Call for Methodological Plurality: Reconsidering Research Approaches in Adult Education. *Adult Education Quarterly*, *68*(2), 157–169. https://doi.org/10.1177/0741713618760560

de Graaff, E. (2016). The Transformation from teaching to facilitation; experiences with faculty development training. *International Journal of Engineering Education*, *32*(1), 396–401.

de Graaff, E., Holgaard, J. E., Bøgelund, P., & Spliid, C. M. (2016). When Students Take the Lead. In R. V. Turcan, J. E. Reilly, & L. Bugaian, *(Re)Discovering University Autonomy: The Global Market Paradox of Stakeholder and Educational Values in Higher Education* (pp. 125–135). Palgrave Macmillan US. https://doi.org/10.1057/9781137388728_9

de Graaff, E., & Kolmos, A. (2003). Characteristics of problem-based learning. *International Journal of Engineering Education*, *19*(5), 657–662.

de Graaff, E., & Kolmos, A. (2007). History of problem-based and project-based learning. In A. Kolmos & A. Kolmos (Eds.), *Management of change* (pp. 1–8). Sense Publishers.

Dolmans, D. H. J. M., Loyens, S. M. M., Marcq, H., & Gijbels, D. (2016). Deep and surface learning in problem-based learning: A review of the literature. *Advances in Health Sciences Education: Theory and Practice*, *21*(5), 1087–1112. https://doi.org/10.1007/s10459-015-9645-6

Dolmans, D. H. J. M., & Schmidt, H. G. (2000). What directs self-directed learning in a Problem-Based Curriculum? In *Problem-based Learning—A Research Perspective on Learning Interactions* (pp. 251–262).

Dunbar, R. L. M., & Dutton, J. M. (1972). Student Learning in a Restructured Environment. *Journal of Research and Development in Education*, *6*(1), 26–39.

Ertmer, P. A., Newby, T. J., & MacDougall, M. (1996). Students' Responses and Approaches to Case-Based Instruction: The Role of Reflective Self-Regulation. *American Educational Research Journal*, *33*(3), 719–752. https://doi.org/10.2307/1163282

Evensen, D. H. (2000). Observing self-directed learners in a problem-based learning context: Two case studies. In *Problem-based Learning—A Research Perspective on Learning Interactions* (pp. 263–297).

Evensen, D. H., Salisbury-Glennon, J. D., & Glenn, J. (2001). A qualitative study of six medical students in a problem-based curriculum: Toward a situated model of self-regulation. *Journal of Educational Psychology*, *93*(4), 659–676. https://doi.org/10.1037/0022-0663.93.4.659

Fellenz, R. (1985). Self-Direction: A Clarification of Terms and Causes. *Adult Education Research Conference*, 164–169.

Ferrell, B. (1978). Attitudes toward learning styles and self-direction of ADN students. *The Journal of Nursing Education*, *17*(2), 19–22.

Field, L. (1989). An investigation into the structure, validity, and reliability of guglielmino's self-directed learning readiness scale. *Adult Education Quarterly*. https://doi.org/10.1177/0001848189039003001

Frederiksen, M. (2020). Mixed methods forskning. In *Kvalitative metoder—En grundbog* (3rd ed., pp. 257–277).

Freeman, F. N. (1917). *How children learn*. Houghton Mifflin Co.

Galletta, A., & Cross, W. E. (2013a). Crafting a Design to Yield a Complete Story. In *Mastering the Semi-Structured Interview and Beyond* (pp. 9–44). NYU Press. https://www.jstor.org/stable/j.ctt9qgh5x.6

Galletta, A., & Cross, W. E. (2013b). *Mastering the Semi-Structured Interview and Beyond: From Research Design to Analysis and Publication*. NYU Press. https://www.jstor.org/stable/j.ctt9qgh5x

Galletta, A., & Cross, W. E. (2013c). The Semi-Structured Interview as a Repertoire of Possibilities. In *Mastering the Semi-Structured Interview and Beyond* (pp. 45–72). NYU Press. http://www.jstor.org/stable/j.ctt9qgh5x.7

Garrison, D. R. (1997). Self-Directed Learning: Toward a Comprehensive Model. *Adult Education Quarterly*, *48*(1), 18–33. https://doi.org/10.1177/074171369704800103

Ge, X., & Chua, B. L. (2019). The Role of Self-Directed Learning in PBL. In *The Wiley Handbook of Problem-Based Learning* (pp. 367–388). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119173243.ch16

Gough, H. G., & Heilbrun, A. B. (1983). *The adjective check list manual* (1983 ed). Consulting Psychologists Press. http://catalog.hathitrust.org/api/volumes/oclc/10535845.html

Griffin, V. R. (1983). *Self-Directed Adult Learners and Learning. PANEL Resource Paper #13*.

Guerra, A., & Kolmos, A. (2011). Comparing problem based learning models: Suggestions for their implementation. In *PBL across the disciplines: Research into best practice. Aalborg: Aalborg Universitetsforlag* (pp. 3–16).

Guglielmino, L. M. (n.d.). *GUGLIELMINO & ASSOCIATES, LLC*. Learning Preference Assessment. Retrieved 13 September 2023, from https://www.lpasdlrs.com/

Guglielmino, L. M. (1977). *Development of the self-directed learning readiness scale (Doctoral dissertation).* [University of Georgia]. https://search-proquest-com.zorac.aub.aau.dk/docview/302856217?pq-origsite=primo

Gyldendahl Jensen, C., Clausen, N. R., Dau, S., Bertel, L. B., & Ryberg, T. (2022). Envisioning scenarios in designs for Networked Learning: Networked Learning Conference 2022. *Networked Learning 2022*. https://www.networkedlearning.aau.dk/digitalAssets/1274/1274674_proceedings-for-the-thirteenth-international-conference-on-networked-learning_.pdf

Gyldendahl Jensen, C., Dau, S., Clausen, N. R., Ryberg, T., & Bertel, L. B. (2022). Dilemmaer i translation og transformation af erfaringsbaserede kollaborative læringsformer til digitale læringsplatforme. *Læring Og Medier*, *15*(25). https://doi.org/10.7146/lom.v15i25.128542

Habermas, J. (1971). *Knowledge and human interests* (J. J. Shapiro, Trans.). Beacon Press.

Han, J.-Y., & Lee, M.-Y. (2009). A Study on Validation of OCLI for Evaluating of Life-Long Learning Ability. *Journal of Engineering Education Research*, *12*(4), 75–83. https://doi.org/10.18108/jeer.2009.12.4.75

Harvey, B. J., Rothman, A. I., & Frecker, R. C. (2003). Effect of an Undergraduate Medical Curriculum on Students Self-Directed Learning. *Academic Medicine*, *78*(12), 1259–1265. https://doi.org/10.1097/00001888-200312000-00015

Harvey, B. J., Rothman, A. I., & Frecker, R. C. (2006). A confirmatory factor analysis of the Oddi Continuing Learning Inventory (OCLI). *Adult Education Quarterly*, *56*(3), 188–200. https://doi.org/10.1177/0741713605286167

Hmelo, C. E., & Lin, X. (2000). Becoming Self-Directed Learners: Strategy Development in Problem- Based Learning. In *Problem-based Learning A Research Perspective on Learning Interactions* (pp. 227–250).

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, *16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Hmelo-Silver, C. E. (2009). What do we know about problem-based learning? Current status and future prospects. *International PBL Symposium, Singapore*.

Holgaard, J. E., Ryberg, T., Stegeager, N., Stentoft, D., & Thomassen, A. O. (2020). *PBL: Problembaseret læring og projektarbejde ved de videregående uddannelser*. Samfundslitteratur. https://samfundslitteratur.dk/bog/pbl

Houle, C. (1961). *The inquiring mind.* University of Wisconsin Press. http://www.worldcat.org/title/inquiring-mind/oclc/1013274

Hung, W. (2011). Theory to reality: A few issues in implementing problem-based learning. *Educational Technology Research and Development*, *59*(4), 529–552. https://doi.org/10.1007/s11423-011-9198-1

Hung, W. (2023). The Other Side of the Promise: Some Precautions for Technology-Based Education. In S. Y. L. Chye & B. L. Chua (Eds.), *Pedagogy and Psychology in Digital Education* (pp. 227–238). Springer Nature. https://doi.org/10.1007/978-981-99-2107-2_13

Hung, W., Jonassen, D. H., & Liu, R. (2008). Problem-based learning. *Handbook of Research on Educational Communications and Technology*, *3*(1), 485–506.

Illeris, K. (1974). Problemorientering og deltagerstyring: Oplæg til alternativ didatik. In *Arbejdstekster til psykologi og pædagogik* (Issue 23). Munksgård.

Illeris, K. (1981). *Modkvalificeringens pædagogik: Problemorientering, deltagerstyring og eksemplarisk indlæring*. Unge Pædagoger.

James, W. (1890). *The Principles of Psychology, volume two*. Dover Publications.

Jude-York, D. A. (1993). Organizational learning climate, self-directed learners, and performance at work. *Dissertation Abstracts International*, *53*(7-A).

Kivela, J., & Kivela, R. J. (2005). Student perceptions of an embedded problem-based learning instructional approach in a hospitality undergraduate programme. *International Journal of Hospitality Management*, *24*(3), 437–464. https://doi.org/10.1016/j.ijhm.2004.09.007

Knowles, M. S. (1970). *The modern practice of adult education: Andragogy versus pedagogy*. Association Press.

Knowles, M. S. (1975). *Self-directed learning—A Guide for Learners and Teachers*. https://doi.org/10.1016/j.jcrysgro.2011.10.051

Knowles, M. S. (1980a). *The modern practice of adult education: From pedagogy to andragogy* (Rev. and updated). Cambridge Adult Education.

Knowles, M. S. (1980b). What is Andragogy? In *The modern practice of adult education: From pedagogy to andragogy* (Rev. and updated, pp. 40–59). Cambridge Adult Education. https://doi.org/10.4324/9780203802670

Knowles, M. S., Holton, E. F., & Swanson, R. A. (2005). *The Adult Learner—The definitive classic in Adult Education and Human Resource Development*. Elsevier.

Kolmos, A., Bøgelund, P., & Spliid, C. M. (2019). Learning and Assessing Problem-Based Learning at Aalborg University. In *The Wiley Handbook of Problem-Based Learning* (pp. 437–458). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119173243.ch19

Kolmos, A., Du, X., Holgaard, J. E., Jensen, L. P., Kolmos, A., Du, X., Holgaard, J. E., & Jensen, L. P. (2008). *Facilitation in a PBL environment*. UCPBL UNESCO Chair in Problem Based Learning.

Kolmos, A., Fink, F. K., & Krogh, L. (2004). The Aalborg model. In A. F. F. K. K. L. Kolmos (Ed.), *The Aalborg model: Progress, diversity and challenges* (pp. 9–18). Aalborg Universitetsforlag.

Kolmos, A., & Ryberg, T. (2023). New realities and PBL futures. In A. Kolmos & Ryberg (Eds.), *PBL in a Digital Age* (pp. 11–26). Aalborg Universitetsforlag.

Kyriazos, T. A. (2018). Applied Psychometrics: Sample Size and Sample Power Considerations in Factor Analysis (EFA, CFA) and SEM in General. *Psychology*, *09*(08), Article 08. https://doi.org/10.4236/psych.2018.98126

Leary, H. (2012). *Self-Directed Learning in Problem-Based Learning Versus Traditional Lecture-Based Learning: A Meta-Analysis*. https://digitalcommons.usu.edu/etd/1173

Leary, H., Walker, A., Lefler, M., & Kuo, Y.-C. (2019). Self-Directed Learning in Problem-Based Learning: A literature review. In M. Moallem, W. Hung, & N. Dabbagh (Eds.), *The Wiley Handbook of Problem-Based Learning* (pp. 181–198). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119173243.ch8

Litzinger, T. A., Wise, J. C., & Lee, S. H. (2005). Self-directed Learning Readiness Among Engineering Undergraduate Students. *Journal of Engineering Education*, *94*(2), 215–221. https://doi.org/10.1002/j.2168-9830.2005.tb00842.x

Long, H. B. (1987). Item analysis of Guglielmino's self-directed learning readiness scale. *International Journal of Lifelong Education*, *6*, 331–336.

Loyens, S. M. M., Magda, J., & Rikers, R. M. J. P. (2008). Self-Directed Learning in Problem-Based Learning and its Relationships with Self-Regulated Learning. *Educational Psychology Review*, *20*(4), 411–427. https://doi.org/10.1007/s10648-008-9082-7

Lutsenko, G. (2018). Case study of a problem-based learning course of project management for senior engineering students. *European Journal of Engineering Education*, *43*(6), 895–910. https://doi.org/10.1080/03043797.2018.1454892

Margarones, J. J. (1961). *Critical requirements of independent study based upon an analysis of critical incidents as observed and reported by students and instructors* [Boston University]. https://open.bu.edu/handle/2144/26838

McCauley, V., & Mcclelland, G. (2004). Further studies in Self-Directed Learning in Physics at the University of Limerick, Ireland. *International Journal of Self-Directed Learning*, *1*(2).

Mezirow, J. (1981). A Critical Theory of Adult Learning and Education. *Adult Education*, *32*(1), 3–24. https://doi.org/10.1177/074171368103200101

Mezirow, J. (1985a). A critical theory of self-directed learning. *New Directions for Adult and Continuing Education*, *1985*(25), 17–30. https://doi.org/10.1002/ace.36719852504

Mezirow, J. (1985b). Concept and Action in Adult Education. *Adult Education Quarterly*, *35*(3), 142–151. https://doi.org/10.1177/0001848185035003003

Oddi, L. F. (1984). *Development of an instrument to measure self-directed continuing learning* [Northern Illinois University]. https://search-proquest-com.zorac.aub.aau.dk/docview/303318103/abstract/2CF04F6547564F81PQ/1?accountid=8144

Oddi, L. F. (1985). Development and validation of an instrument to identify Self-Directed continuing learners. *Adult Education Research Conference*, 229–235.

Oddi, L. F. (1986). Development and validation of an instrument to identify self-directed continuing learners. *Adult Education Quarterly*, *36*(2), 97–107. https://doi.org/10.1177/0001848186036002004

Oddi, L. F. (1987). Perspectives On Self-Directed Learning. *Adult Education Quarterly*, *38*(1), 21–31. https://doi.org/10.1177/0001848187038001003

OECD. (2019). *Trends Shaping Education 2019*. OECD Publishing. https://doi.org/10.1787/trends_edu-2019-en

OECD. (2022). *Trends Shaping Education 2022*. Organisation for Economic Co-operation and Development. https://www.oecd-ilibrary.org/education/trends-shaping-education-2022_6ae8771a-en

Owen, R. T. (2002). *Self-Directed Learning in Adulthood: A Literature Review*. 57.

Penland, P. (1979). Self-Initiated learning. *Adult Education Quarterly*. https://doi.org/10.1177/074171367902900302

Peters, J. M., & Gordon, R. S. (1974). *Adult Learning Projects: A Study of Adult Learning in Urban and Rural Tennessee*. https://eric.ed.gov/?id=ED102431

Rogers, C. (1951). *Client-centered therapy: Its current practice, implications, and theory*. Houghton Mifflin Co.

Rogers, C. (1958). Personal Thoughts on Teaching and Learning. *Improving College and University Teaching*, *6*(1), 4–5.

Rogers, C. (1969). *Freedom to Learn: A View of What Education Might Become* (1st ed.). Charles Merill.

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs*, *80*(1), 1–28.

Savery, J. (2006). Overview of Problem-Based Learning: Definitions and Distinctions. *Interdisciplinary Journal of Problem-Based Learning*, *1*. https://doi.org/10.7771/1541-5015.1002

Savery, J. (2015). Overview of problem-based learning: Definitions and distinctions. *Essential Readings in Problem-Based Learning: Exploring and Extending the Legacy of Howard S. Barrows*, 5–15.

Savin-Baden, M. (2014). Using Problem-Based Learning: New Constellations for the 21st Century. *Journal on Excellence in College Teaching*, *25*, 197–219.

Schmidt, H. G. (2000). Assumptions underlying self-directed learning may be false. *Medical Education*, *34*(4), 243–245. https://doi.org/10.1046/j.1365-2923.2000.0656a.x

Schwarzer, R., & Jerusalem, M. (1995). Generalized Self-Efficacy scale. In *J. Weinman, S. Wright, & M. Johnston, Measures in health psychology: A user's portfolio.* NFER-NELSON.

Selwyn, N. (2011). *Education and Technology: Key Issues and Debates*. Bloomsbury Publishing. http://ebookcentral.proquest.com/lib/aalborguniv-ebooks/detail.action?docID=661054

Servant-Miklos, V. (2020). Problem-oriented Project Work and Problem-based Learning: 'Mind the Gap!' *Interdisciplinary Journal of Problem-Based Learning*, *14*(1), Article 1. https://doi.org/10.14434/ijpbl.v14i1.28596

Servant-Miklos, V., & Noordegraaf-Eelens, L. (2021). Toward social-transformative education: An ontological critique of self-directed learning. *Critical Studies in Education*, *62*(2), 147–163. https://doi.org/10.1080/17508487.2019.1577284

Servant-Miklos, V., Norman, G. R., & Schmidt, H. G. (2019). A Short Intellectual History of Problem-Based Learning. In *The Wiley Handbook of Problem-Based Learning* (pp. 3–24). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119173243.ch1

Shostrom, E. L. (1964). AN INVENTORY FOR THE MEASUREMENT OF SELF-ACTUALIZATION*. *Educational and Psychological Measurement*, *XXIV*(2), 207–218.

Six, J. E. (1989). The Generality of the Underlying Dimensions of the ODDI Continuing Learning Inventory. *Adult Education Quarterly*, *40*(1), 43–51. https://doi.org/10.1177/074171368904000105

Sørensen, M. T. (2022). *Students' orchestration of groupwork and the role of technology*. Aalborg Universitetsforlag.

Statacorp. (2019). *Stata Statistical Software: Release 16* (Release 16) [Computer software]. StataCorp LLC.

Stockdale, S. L. (2003). *Development of an Instrument to Measure Self-Directedness*. https://trace.tennessee.edu/utk_graddiss/1619

Stockdale, S. L., & Brockett, R. G. (2011). Development of the PRO-SDLS: A Measure of Self-Direction in Learning Based on the Personal Responsibility Orientation Model. *Adult Education Quarterly*, *61*(2), 161–180. https://doi.org/10.1177/0741713610380447

Straka, G. A. (1996). Construct validation of the Oddi Continuing Learning Inventory. In *Current developments in Self-Directed Learning.* (pp. 65–80). Classic Book Distributors.

Sungur, S., & Tekkaya, C. (2006). Effects of Problem-Based Learning and Traditional Instruction on Self-Regulated Learning. *The Journal of Educational Research*, *99*(5), 307–320. https://doi.org/10.3200/JOER.99.5.307-320

Taylor, E. W. (2001). Adult Education Quarterly from 1989 to 1999: A Content Analysis of All Submissions. *Adult Education Quarterly*, *51*(4), 322. https://doi.org/10.1177/07417130122087322

Thorndike, E. L., Bregman, E. O., Tilton, J. W., & Woodyard, E. (1928). *Adult learning*. Macmillan Co. http://catalog.crl.edu/record=b2877676

Tough, A. (1966). The assistance obtained by adult self-teachers. *Adult Education*, *17*(1), 30–37. https://doi.org/10.1177/074171366601700105

Tough, A. (1967). *Learning without a teacher: A study of tasks and assistance during adult self-teaching*. Ontario Institute for Studies in Education, Toronto, Ontario, Canada.

Tough, A. (1971). *The Adults Learning Project—A Fresh Approach to Theory and Practice in Adult Learning*. Ontario Institute for Studies in Education.

Tough, A. (1978). Major Learning Efforts: Recent Research and Future Directions. *Adult Education*, *28*(4), 250–263. https://doi.org/10.1177/074171367802800403

Tough, A. (1982). *Intentional changes: A fresh approach to helping people change.* Follett.

Tough, A., & Knowles, M. S. (1985). Andragogy in Action: Applying Modern Principles of Adult Learning. *The Journal of Higher Education*. https://doi.org/10.2307/1981081

Uddannelses- og Forskningsministeriet. (2023). *Frafald på første studieår*. Uddannelses- og Foskningsministeriets datavarehus. https://datavarehus.ufm.dk/rapporter/frafald

UNESCO. (2017). *Sustainable Development Goals*. http://en.unesco.org/sdgs

Vallerand, R. J., Pelletier, L. G., Blais, M. R., Briere, N. M., Senecal, C., & Vallieres, E. F. (1992). The academic motivation scale: A measure of intrinsic, extrinsic, and amotivation in education. *Educational and Psychological*

Measurement, *52*(4), 1003–1017. https://doi.org/10.1177/0013164492052004025

Walker, A., & Leary, H. (2009). A Problem Based Learning Meta Analysis: Differences Across Problem Types, Implementation Types, Disciplines, and Assessment Levels. *Interdisciplinary Journal of Problem-Based Learning*, *3*(1). https://doi.org/10.7771/1541-5015.1061

Webb, E. J., Campbell, D. T., Schwartz, R. D., & Sechrestm, L. (1966). *Unobtrusive Measures—Nonreactive Research In The Social Sciences*. Rand Mcnally.

West, R., & Bentley, Jr., E. L. (1991). Relationship between scores on the self-directed learning readiness scale, Oddi continuing learning inventory and participation in continuing professional education. In *Self-Directed Learning: Consensus & Conflict* (pp. 71–92). Oklahoma Research Center for Continuing Professional and Higher Education, McCarter Hall, University of Oklahoma, Norman, OK.

Wieland, A., Kock, F., & Josiassen, A. (2018). Scale purification: State-of-the-art review and guidelines. *International Journal of Contemporary Hospitality Management*, *30*(11), 3346–3362. http://dx.doi.org.zorac.aub.aau.dk/10.1108/IJCHM-11-2017-0740

Williamson, B. (2019). New power networks in educational technology. *Learning, Media and Technology*, *44*(4), 395–398. https://doi.org/10.1080/17439884.2019.1672724

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